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A STEAM MOTOR CAR FOR RAILWAY SERVICE.

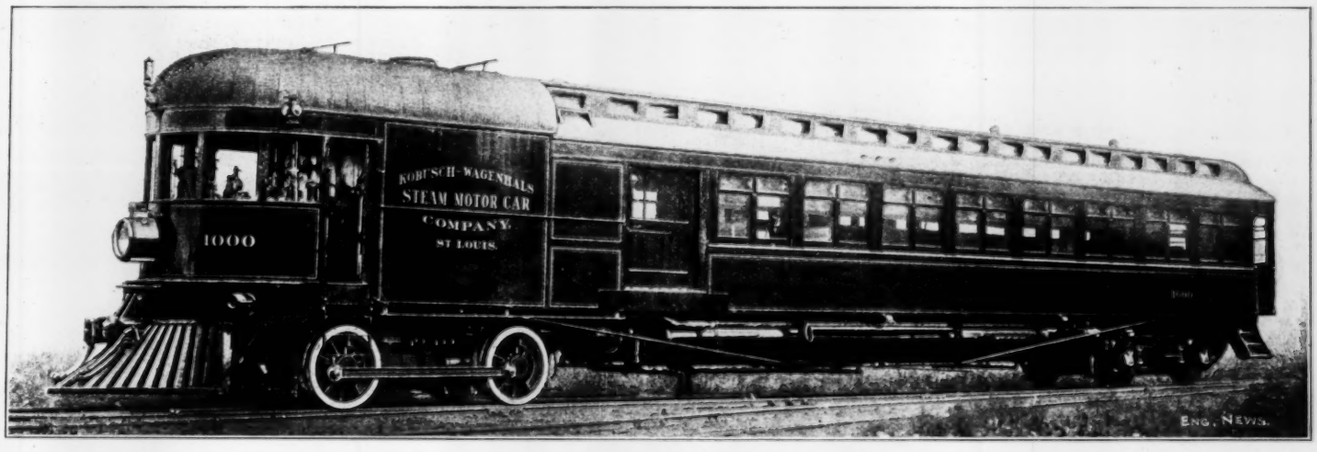
In the recent developments in the design of motor cars for railway service in this country there have been numerous applications of gas engines (for direct power or for generating electric current), but one of the latest motor cars for railways is driven by steam generated in a high-pressure water-tube boiler. The car resembles a large electric interurban car, as shown herewith, and has the engine room and the steam truck at the front end. The machine was designed by Mr. W. G. Wagenhals, and is being introduced by the Kobusch-Wagenhals Steam Motor Car Co., of St. Louis, Mo. The first car has been built by the St. Louis Car Co., and is to be tried on the Missouri Pacific Ry.

The engine does not drive directly to the axles, but through a pair of gear wheels, as shown in Fig. 2. Between the axles of the steam truck are two horizontal cylinders, A, connected to crank disks on the end of a countershaft, B, having a 21-in. pinion (36 teeth); this gears with a 24-in. pinion (44 teeth) on the front axle, C, and the four 42-in. driving wheels are connected by coupling rods in the usual way. Piston valves are used with link valve gear, operated from eccentrics on the countershaft; special mechanism is required to prevent the movement of the truck from interfering with the control of the valve gear. The connecting rods are enclosed in crank cases, D, for splash lubrication, and the gearing is also encased. The engine has a triple-support arrangement; the engine frames are connected at the rear end by a cross frame supported from above by a hanger, E, resting on springs seated on cross bars above the truck frames; at the front end, the engine frames rest on the driving axle, extending far enough beyond it to be connected by a cross bolt and brace, F. The motor truck can easily be disconnected and run out from the car.

The boiler is of the Roberts type, built by the Roberts Safety Water Tube Boiler Co., 39 Cortlandt St., New York City; the general design is shown in Fig 3. The horizontal drum has an outflow connection at each end to a large cross pipe, A, with downflow legs, B, connected at the bottom by headers, C, parallel with the drum. To these headers are connected the vertical ends of a series of pipe coils which lie above the grate, the upper ends of the coils being connected with the drum. A perforated pipe in the top of the drum is connected to the superheating coils, D, at the sides, and these in turn are connected by the branch pipes, E, with the main steam pipe, at F. Hollow firebrick blocks are placed at the sides of the grate. The boiler made for the steam car differs from the arrangement shown, in that the coils over the furnace extend from each side to the middle, instead of from side to side. It is about 8 ft. square, and was tested with live steam at 250 lbs. pressure. Oil fuel is used, with five burners of the pattern made by the National Supply Co., Chicago. The oil for fuel is carried in a tank under the car, and two other tanks carry the feed water, which is heated by coils, G, at the upper part of the boiler, and delivered by a feed pump. The 3½-in. steam pipe passes down through the floor and ends in a swivel joint connected by a horizontal pipe (with an expansion joint) to a similar flexible joint in front of the center casting of the truck. Beyond this are two 2½-in. pipes passing on either side of the center casting to the valve chambers. The exhaust pipes are connected to a single 4-in. pipe which passes up through the hollow center casting and extends to the smokestack.

The car has an underframe of steel, and at the rear end is a four-wheel truck. The rear of the body forms the main saloon, with seats for 52 persons; next to this is the smoking compartment, with seats for 12 persons. Beyond this is the baggage room (10 ft. long) and then the engine room (12 ft. long), this latter being lined with steel. The car is intended for a speed of 40 miles an hour. It is fitted with air brakes and steam heating equipment. The principal dimensions are as follows:

Driving wheels	3 ft. 6 ins.
Wheelbase, c. to c. of trucks	53 " 0 "
Length	82 " 6 "
Width	10 " 0 "
Height to top of smokestack	15 " 2 "
Weight on driving truck	115,000 lbs.
Weight, total	178,600 "
Tractive effort	8,000 "
Cylinders	11 × 12 ins.
Boiler pressure	250 lbs.
Heating surface	1,200 sq. ft.
Grate area	41½ sq. ft.
Oil fuel in tank	1,000 gals.
Water in tanks	2,000 "



A STEAM MOTOR CAR.

COST-KEEPING IN THE U. S. RECLAMATION SERVICE.*

In the operations of the U. S. Reclamation Service special attention has been paid to the matter of keeping accurate accounts of cost, not merely of the amounts expended for work, but as to the actual cost of important structures and details of construction. The work is widely scattered in various parts of the United States under various climatic conditions and usually away from facilities for transportation, at points where supplies are obtained with difficulty.

The operations embrace a wide variety of work, from survey and examination up through construction to maintenance and operation of large hydraulic systems. Included within these are the building and operation of wagon roads, telephone lines, power plants, and, in some cases, of manufacturing establishments or small mills for making cement, lime, or brick, for crushing sand, etc.

To meet all the various requirements of the Service it has been necessary to make a very careful study of the methods of cost-keeping as practiced by contractors and manufacturers. The results of the experience thus obtained by the

*A statement prepared by the U. S. Reclamation Service, followed by some extracts from the "Manual of Field Accounting" described herewith. Mr. F. H. Newell, M. Am. Soc. C. E., of Washington, D. C., is Director of the U. S. Reclamation Service.

Reclamation Service have been embodied in a small book. This "Manual of Field Accounting" has been prepared by Norman E. Webster, Jr., Accountant for the Reclamation Service, and E. G. Lind, Field Inspector, the latter having had practical experience for several years in cost-keeping at the operations in Roosevelt, Ariz. Mr. Webster has served as chairman of a subcommittee of the President's Committee on Department Methods, and as such has taken the initiative in the preparation of what is known as the "Primer of Cost Keeping on Government Work."

The details of cost keeping, as shown by this little manual, are particularly adapted to work for the Government and are also suggestive for engineers in various lines of work, whether engaged in State, municipal, or corporate enterprises. The attempt has been made to secure simplicity and to reduce as far as practicable the number of clerks necessary to produce a given result. In any such system it is, of course, absolutely essential to ascertain in advance what is the character of the results which it is desired to accomplish, and to lay down a scheme for stating results so that the final outcome will have value; that is to say, the executive officer must determine as to what class of work or output he desires the accurate cost. If these matters are made too minute and an attempt is made to secure the cost of every little article, the results may be of very little value, and the cost of obtaining these may far exceed the worth of the information. On the other hand, if the items are not sufficiently well classified the resulting totals are of correspondingly little use.

Having determined the general character of the information which it is desired to obtain, the methods which are prescribed in the Manual of Field Accounting can be adapted to obtaining these results with the minimum of labor. There are, of course, a number of details which must be smoothed out in practice. It is to be noted that no system of cost-keeping will be successful unless it is used with intelligence. It is necessary to mix brains with the operations in this as well as in any other occupation.

Copies of blanks [nearly a hundred in number.—Ed.] and of the Manual of Field Accounting can be had upon application to the Director of the Reclamation Service.

[Some extracts from the "Manual" are appended.—Ed.]

ENGINEERING CONSTRUCTION COSTS.

There is no subject in which there has been such constant and growing interest within the last decade as in engineering construction costs. The importance of systematic records of cost of work is fast becoming fully realized. The Reclamation Service, as well as modern manufacturers, contractors, and engineers in general, are initiating methods of obtaining this kind of information and are attempting to put it to practical use.

The purpose of keeping such costs is two-fold: (1) it enables the engineer to adopt the most economical methods and to select, arrange, and operate his machinery and men in the most economical manner; (2) it enables him to estimate and analyze the cost of proposed work with intelligence and precision. Engineering construction costs are, therefore, the fundamental data of estimates and execution of engineering work; and the engineer who tries to get along without them draws conclusions without known premises. The almost inevitable results of such conclusions are extravagance and loss.

For the first purpose, a sufficiently minute classification is requisite to give the engineer a clear conception of the results which are being accomplished, thereby enabling a comparison of cost of work in one locality, or cost of any particular feature of the project with the cost of similar work, or of a similar feature elsewhere located. To fully meet this requirement, careful, but not too minute, classification is requisite. For the second purpose, information in detail carefully classified is required, but indefinite duplication of results is of continually decreasing value.

To secure uniformity in the keeping of cost accounts, and to insure that cost-keeping is carried sufficiently far to be advantageous, and, on the other hand, to insure that it is not carried too far to be practical, the following rules should be observed:

(1) Separate accounts should be kept for each project feature that is estimated to cost more than $1,000.

(2) Features ranging in cost from $300 to $1,000 may or may not be treated separately, at the option of the supervising engineer, according to local condition; and

(3) Small similar features, each estimated at less than $300, shall be grouped, unless special reason exists for treating one or more thereof separately.

PROJECT, DAILY AND MONTHLY FEATURE REPORTS AND PROJECT ENGINEERS' COST DATA CARDS.

Engineers, superintendents, foremen, and others having charge of structural or building work of any description should send in to the project office a daily report showing the number and classification of men and animals employed on certain features of that work, the rate of pay, unit of cost, etc. This report should also include the cost of such items as sacks of cement, lumber, structural iron, and other material or supplies used or entering into the work. These figures can be obtained from the copies of the requisition blanks returned. The final results should then be shown—such as number of feet of pipe made, cubic yards of concrete placed, cubic yards of rip-rapping laid, or cubic feet of tunnel driven, and the unit cost. These statements should then be followed up with remarks as to distance from the nearest railroad point of shipment; weather conditions (extremes of temperature); labor conditions (difficulty of obtaining men, high or low price paid); road conditions (whether they are in good or poor shape for traveling, and likely to affect the costs of hauling of materials or supplies), and market conditions (inability to obtain materials or supplies on account of shortage, etc., etc.). In short, the remarks should be made so comprehensive as to take into consideration any condition, usual or unusual, which might contribute in any way to affect the unit cost—such as floods, fires, etc.; for, as this information will go later into the project monthly cost report, which is sent to the office of the Chief Engineer,* it can not be too complete, for that office will send out cost data in comparative form to all projects, and unless these conditions are fully set forth the data would be of very little practical value.

It has been found to be impracticable to furnish uniform blanks for these feature reports. The work on all the projects is so diversified and the operations which are being carried on vary in so many different ways, the desires of individual engineers as to what should be the analysis of certain costs are so varied that it would appear best to have these forms mimeographed at the project offices and sent out to those who are to use them. In some cases, when the same class of work will be done daily for a long time, purchase orders for the printing of such blanks may be sent to the office of the Chief Engineer. These forms, if mimeographed locally, can be revised from time to time, at the instance of the project engineer and his cost clerk, after consultation with those who are to use them. These daily reports should show not only the amount of work done each day on a particular project feature and give the cost of the same, but act as a check on the timekeeper and show the project office whether the various engineers, superintendents, foremen, and others are exercising good judgment in making requisitions on the storehouses, etc. These daily reports should, as far as practicable, be checked against the time books at the end of the month. They also enable the project engineer to watch carefully every item of cost entering into a particular piece of work and make it possible for him to stop excessive charges at any date without waiting until the end of the month. Daily feature reports from several projects have been printed as samples.

These daily feature reports should at the end of the month be supplemented by a monthly feature report, which can be made up in the office. These reports would embody practically all the information contained in the daily reports and should be sent out to all engineers, superintendents, foremen, and others who are doing the same class of work. Such a plan has been found to engender a friendly spirit of rivalry among those concerned which generally results in smaller cost and better work.

Under the heading of monthly feature reports would

[*Since the main part of the "Manual" was printed, the title of the executive officer of the U. S. Reclamation Service has been changed to Director.—Ed.]

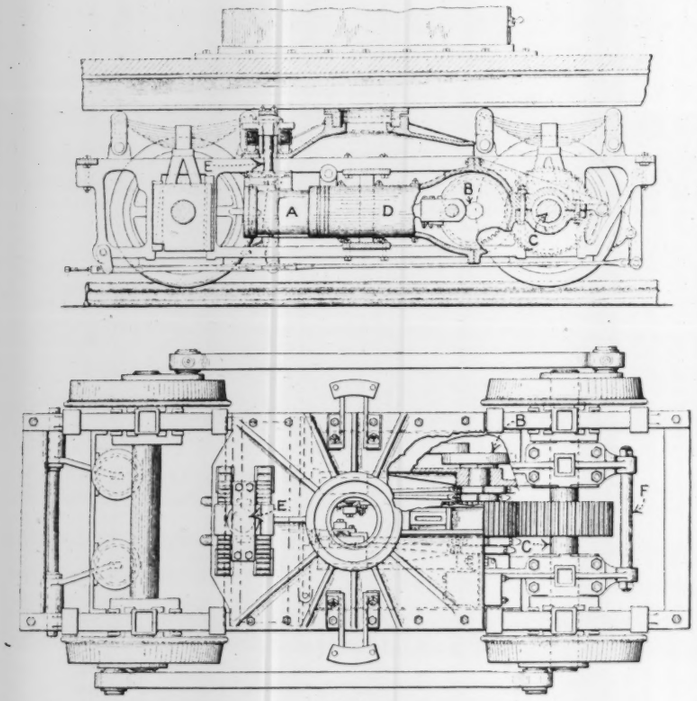


FIG. 2. MOTOR TRUCK OF WAGENHALS STEAM CAR.

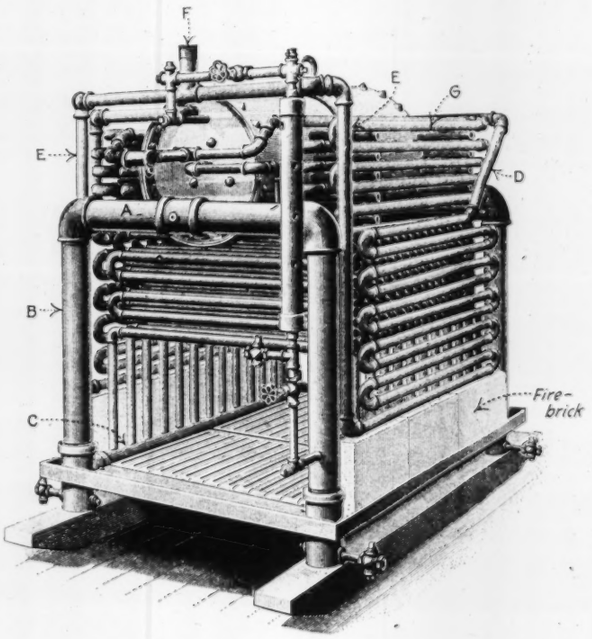


FIG. 3. BOILER FOR STEAM CAR.

also be classed such comparative reports as subsistence and forage. Such reports should be based on an inventory which all camps or corrals would be required to turn in promptly at the end of each month. When these comparative reports have been made out, copies should be sent to each steward, cook, corral foreman, or others interested, generally with the result that costs are kept down. These reports are also necessary in order that the project may not be subsisting its employees at a loss of money. In cases where the cost of feeding either an employee or an animal is found to be excessively high, the attention of those responsible for the conduct of the particular camp should be called to the matter in order that abuses may be corrected. A few samples of monthly feature reports have been printed.

Each project engineer should have on his desk a card cabinet showing such costs as subsisting various camps, feeding animals, concreting, excavating, and the many subdivisions of his project work. These cards may be arranged to show comparison by months of features finished or incomplete, etc., so that the project engineer may always be in a position to know at any time not only what a finished structure has cost the project, but what one is costing from day to day. The cost clerk should see that the project engineer is relieved of any detail work in obtaining these cost figures, and that the engineer's wishes are anticipated in procuring cost information. These cards should be accompanied by sketches and such notes as will explain readily any apparently excessive prices. Such a card system enables the engineer to issue frequent instructions to his subordinates in regard to the cost or amount of their work, and also aids him in making special reports on certain project features to the Chief Engineer. These cost data are valuable not only to the local or project engineer, but also to the Chief Engineer, who is, on account of such data, better able to figure on work of a similar nature.

The value of the cost data kept by the project engineer will depend largely upon the daily and monthly feature reports, and reference will have to be made to them in order to make out the monthly project cost report for the Chief Engineer.

As in the case of daily and monthly reports, it has been found impossible to devise a form or size of card acceptable to all projects, and therefore these details are left to the project engineer and his cost clerk. Samples of cards used on certain projects have been printed.

CONTRACTOR'S COSTS.

The reasons for the determination of contractor's costs are to furnish information in regard to (A) the profits or losses of the contractor; (B) the probable ability of the contractor to complete his contract; and (C) unit costs which are of value in determining estimates of cost and reasonableness of bids for future similar work.

The plans outlined in the foregoing pages contemplate the handling of such cost accounts as the project engineer may desire to be kept, and where he has control of the organization this may be readily accomplished, but in obtaining costs of contractor's work, individual preference and ingenuity must largely govern the method of procedure. As a general rule it would be well to induce the contractor to use the forms prepared for the use of the Reclamation Service, to furnish him the forms without cost, and even to engage the services of his timekeepers in this work. Most contractors engaged in construction work for the Reclamation Service have no particular system of accounting, this being particularly true of such contractors as sublet their work, who are interested only in obtaining their particular profit. It will be difficult to get such a contractor to adopt an up-to-date accounting scheme; but where a contractor is not subletting his work, he may be only too glad to use the Service forms, particularly if it were made an object to him. Such a plan would work to the advantage of the contractor as well as to the Reclamation Service, as it would mean a direct check on his expenditures, and serve to save the contractor money. With the contractor who has his own system of accounting, however, it would be difficult to make any such arrangement, in which case the duties of timekeepers, inspectors, and others on this class of work, will be made much more arduous. A number of plans for obtaining this class of information have been formulated by members of the Reclamation Service, each one showing considerable thought and study, but differing in all essential features. Probably every engineer in the Service has some plan for collecting contractor's costs, and the following, based largely upon all of these plans, is offered for consideration:

A comprehensive method of cost keeping must be based on a logical analysis of the elements of cost pertaining to the work under consideration. The degree to which the analysis should be carried depends on the magnitude of the work. On small jobs a close analysis is both practical and desirable, but on large works of varied character, such as those being constructed by contractors for the United States Reclamation Service, in which the necessity for a method adapted to all items of classification of work exists, it is not advisable to enter into laborious refinement. For such engineering work the methods adopted by the Reclamation Service require the distribution of costs under the following heads: interest investment; preparatory expenses; plant depreciation; materials; supplies; executive; labor and engineering. These heads are defined to cover expenses as outlined below: (1) Investment interest. All charges for insurance, bond premium, and interest on cash and borrowed capital. (2) Preparatory expenses. All charges for the construction of roads, erection and drainage of camps, delivery and installation of plant and other expenses involved before the actual construction begins. (3) Plant. All charges for repairs, and the depreciation of all property employed in the operations by which the finished product is made, but which does not enter that product and is not consumed in such operations, excepting as to wear and tear. Plant includes real estate and improvements thereon, vehicles, animals owned, etc. (4) Materials. All charges, including freight, for property that enters into and remains a part of the finished product. Materials often refers to raw material, but it should be noted that the finished product of one operation, sometimes called stock, often becomes the raw material of a subsequent operation, and is then designated in the latter organization as stores. (5) Supplies. All charges, including freight, for property that is used upon and wholly consumed in the operations by which the finished product is made. (6) Executive. All charges for salaries of superintendents, foremen, time keepers, clerks, watchmen, and for other general administrative expenses. (7) Labor. All charges for hire of teams and of skilled and common labor not classified in executive. (8) Engineering. All charges for salaries of engineers and inspectors.

The distinction between materials, supplies, and plant is not always an easy one to make in advance of their use, though when the articles are actually employed in productive operations there should be no difficulty in deciding into which class any article should go. In some instances the same substance is differently classified, according to the disposition that will be made of it. Timber may be sawed into lumber and become material for the manufacture of furniture, or it may be transformed into plant by the enlargement of the factory, or it may be cut into cord wood and become supplies for use as fuel.

But whether it is easy or difficult in any case to draw the distinction between the three classes of stores, the reason for such distinction is sound. It is possible to measure the quantity of materials used in each article of the project, and there need be no estimate whatever. It is possible to measure the quantity of supplies used upon the product for a certain period, but an estimate is necessary in distributing such expense. It is impossible to measure accurately depreciation or wear and tear of plant, and both the amount of such expense and its distribution must rest on estimates. It is plain that the most accurate results are obtained by so classifying expenses as to group those in which the elements of uncertainty and estimate are absent or at the minimum or at the maximum.

In order to distribute the costs properly in this system, they should be charged directly to the items of the contract to which they apply, where possible, and should be otherwise prorated during the continuance, or at the completion of the contract. For the purpose of facilitating the keeping of costs and of giving full value to the results, the contract items should be carefully classified in specification schedules, so as to require bids on each distinctive class of work having a common cost.

The collection of data for this method of cost keeping should be made by means of the time and material distribution system. In the timebook several pages should be devoted to the records of a single contract item, the entries being made under the heads of Engineering, Executive, and Labor. The timebook may also be used as a material book, in which charges against each contract item should be similarly made under the heads of Plant, Material, and Supplies, etc.

The information contained in the time and material books should then be carried forward at the end of each day to the general classification book, and at the end of the month, the totals shown in this book should be carried to separate leaves in the same book, after entries have been made for the monthly estimates, and unit costs have been distributed under the various headings. It may frequently happen that the cost keeper on contractors' cost may be able to apply the principles of the account number system in distributing his costs in the general classification book; and when this is feasible, it should be done. If it is not feasible, however, he should insert the names instead of the number, but this is left to his own discretion.

In this general classification book accounts should be carried with each item of the contract, secondary charges being made under the proper heads hereinbefore mentioned. Certain charges, such as those against investment interest, preparatory expense, and portions of others, are necessarily carried forward en masse until the completion of the contract, at which time distribution is made among the items of the contract. The methods employed in collecting contractors' costs are those which pertain to ordinary construction work with such variations as may be necessary in each case. Statistics of productive labor, materials, and supplies are collected by inspectors. Unit prices of labor, materials, and supplies may be assumed at market rates, or, if the contract requires it, as is frequently the case, the contractor may be requested to furnish these and other data which cannot be readily collected by inspectors. It may be necessary and desirable to estimate many of the details of such costs. For example, in the case of horses owned by the contractor, it is frequently more satisfactory to reckon the cost of their work on the basis of current rates for hiring animals rather than to determine the cost of maintaining them and to estimate depreciation, etc.

While figures are always essential to the usefulness of cost data, it is recognized that a complete knowledge of the conditions affecting component prices is equally imperative. The character of machinery, the conditions of labor, the geography of the work, the topography of the site of the work, the proximity of constructing material, the condition of the weather, and other similar circumstances are all important matters for record. Entries in the time books of these elements of cost should, therefore, be made by the timekeepers. The costs as reported should be divided into two parts: (A) those which are determined accurately, and (B) those which are estimated. The accompanying explanations should be so complete that other persons using the data may be able to judge their value and the limits of their accuracy.

In addition to keeping the field records, as outlined above, it is essential to keep the office of the Chief Engineer informed of the monthly progress and cost of the work being done in the field. For this purpose blank forms have been devised. These cost sheets have been so designed as to make it possible to copy the information required by them directly from the engineering costs, as shown in the general classification book. In the use of these forms it is imperative that each engineer be painstaking in filling out all of the details of each sheet, and in transmitting them as promptly as possible after the end of each month.

At the completion of each contract the accounts of the items thereof should be closed after making the proper distributions of the various expenses on all of the items. The office of the Chief Engineer should then be immediately supplied with the resulting data. For the transmission of this information a blank form has been prepared. This form is intended to incorporate a report on and an analysis of the cost of one item of a contract, both the contractor's cost, and the actual construction cost, a separate sheet, therefore, being used for each item of the contract schedules.

After the completion of the various classifications for each month's business, the sheets can be taken out of the general classification book and filed for future reference, but the sheets kept in the back of the book should be left in the binder, unless the cost keeper desires to carry these records forward to a regular ledger form, the use of which is left optional with him, but it is not advised.

If, however, the use of any form of ledger seems absolutely necessary in collating contractor's costs, the cost ledger should be used.

EIGHT 72-TON SINGLE-PHASE ELECTRIC LOCOmotives have been ordered from the Westinghouse Electric Co. for the Spokane & Inland Empire Railway Co., of Washington. This railway, which runs from Spokane, Wash., to Lockport, Idaho, a distance of 130 miles, was one of the first in this country to adopt the alternating current single-phase system. It began operations over a year ago with seven single-phase electric locomotives, operating express, local and freight trains, and the phenomenal growth of business is well shown by this new order for an additional equipment of eight locomotives.

A MOTOR TRAIN SERVICE has been instituted on the Dublin and Howth line of the Great Northern Ry. of Ireland. Instead of using the motor-car system, a small tank locomotive of the 4-4-0 class is used, coupled between two specially-built cars, which are mounted on four-wheel trucks. The engine has cylinders 15 × 18 ins., 55-in. driving wheels, and a wheelbase of 17 ft. 7 ins. The cars are 53 ft. long, with compartments for first and second class passengers and baggage. At the outer end of each car is a compartment for the engineman, the fireman being alone in the cab. The length of the line is 8½ miles, and the trip is made in 22 minutes. The same railway operates a steam car on its Belfast and Lisburn line, making the 7½ miles in 25 minutes, with five intermediate steps. The car is 65 ft. long over the buffers, having an ordinary car truck at one end and the steam truck at the other end. A vertical multitubular boiler is used, and the engine has outside cylinders, 12 × 16 ins., with slide valves and the Walschaert valve gear. The wheels are 45 ins. diameter, with a wheelbase of 8 ft. This car seats 59 passengers of two classes, with a separate smoking compartment for each class. Coupled to the motor end of the car is a trail car 51 ft. long, seating 78 second-class passengers, the engine being controlled from an end compartment at each end of the train. The Gold steam heating system and Stone electric lighting system are used.

REINFORCED CONCRETE RETAINING WALL DESIGN.

By EVAN P. BONE.*

The earth pressure against a retaining wall is a very uncertain quantity. The laws of action of the forces causing earth thrust are so intricate and variable that it would take a very complex mathematical theory to cover the case and the approximate theories which have been devised, although beautiful from a mathematical point of view, give results inadequate for practice. For this reason it has been the custom to design walls more by direct assumptions or "good judgment" than by calculations, but the application of reinforced concrete to retaining walls calls for a more careful design. Even if it is not known what the earth thrust is going to be, it certainly is good practice to proportion the materials so that all members of the wall will be equally safe. The use of a large quantity of material and a liberal expenditure of money do not necessarily mean a strong wall. The engineering problem is to make what material is used count for the most possible by designing the wall so that no part will be proportionally weaker than another. To do this it is not sufficient to assume a certain earth thrust and then design a wall making all members safe and say that it is a safe wall, for under another load than the one assumed, the stresses in the different parts of the wall may be altogether differently distributed. It may even happen that a smaller load than the one assumed will cause greater stresses in some parts of the wall. It is therefore necessary to investigate the strength of the wall for every load under which it is required to stand and not simply for the maximum load, the calculated load or any other specific load.

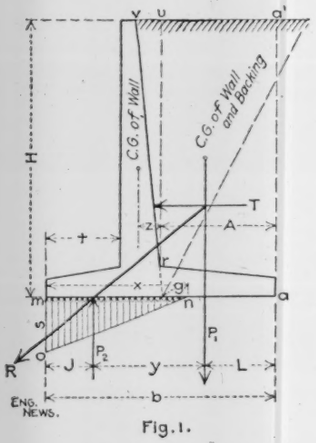


Fig. 1.

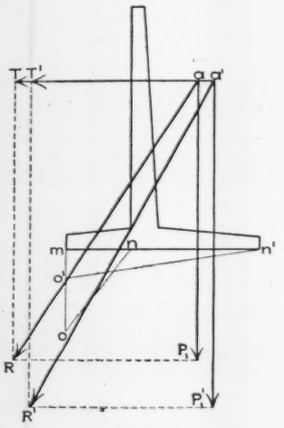


Fig. 2.

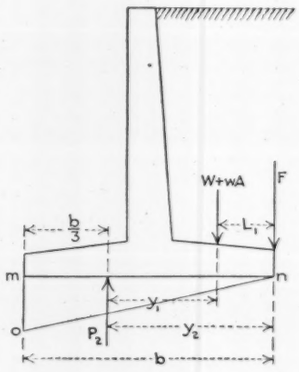


Fig. 3.

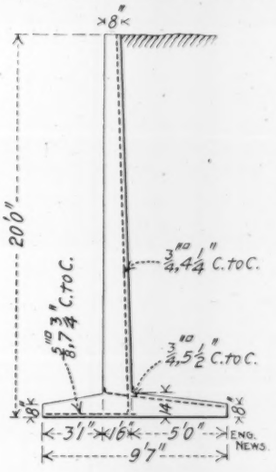


Fig. 4.

The reason for first building reinforced concrete retaining walls was the economy of construction compared with gravity retaining walls of solid concrete or stone masonry; but a better and more scientific wall can be made of reinforced concrete than of simple masonry, if proper care is taken in designing. By the use of a broad base and a reinforced concrete toe extending to the front of the reinforced wall to distribute the pressure on the foundation bed, the unit pressure can be kept well within the limits of the bearing power of the particular kind of earth on which the wall is built. Such flexibility of design is not possible with a gravity wall. In designing a gravity wall the resultant pressure must be made to strike the base within the middle third so that there will be no tensile stresses in the back of the wall. But in a reinforced wall this tension is cared for by the reinforced heel acting as a cantilever beam and so the resultant is not limited to the middle third, but may strike out near the end of the toe, when on a solid foundation. On the other hand, when the foundation bed is of a material liable to serious settlement the toe can be so extended as to cause the resultant to strike the base in the middle. This will make the unit pressure on the foundation uniform and the settlement the same all along the base. This is not possible with a gravity wall where the pressure, and consequently the settlement, is greater under the toe, throwing the wall out of plumb and decreasing its stability.

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THEORY OF DESIGN.

In accordance with the following theory, the table and charts for the graphical design of reinforced concrete retaining walls which accompany this article have been prepared.

To obtain formulas giving the proper proportions and size which a wall should have under these different conditions, the following symbols will be used together with those shown in Fig. 1.:

H=Height of wall in ft.

b=Length of base or footing in ft.

t=Length of toe in ft.

A=Length of heel in ft. = a on charts.

W=Weight of wall in lbs., including weight of triangle rvu in backing.

w=Weight of one cu. ft. of backing multiplied by H.

s=Maximum unit pressure on foundation bed in lbs. per sq. ft.

s_1=Ultimate bearing power of earth in lbs. per sq. ft.

T=Ultimate earth thrust for height (H) in lbs.

M=Overturning moment of wall under thrust T.

F=Force of friction in plane aa'.

P=W + wA + F=Total weight or downward pressure of wall and backing.

μ=Coefficient of friction of wall on foundation.

μ'=Coefficient of friction in plane aa'.

All values are considered for one linear foot of the wall.

A reinforced wall may fail (1) internally (failure of concrete steel beams) or (2) externally. It may fail externally (a) by overturning or (b) by sliding bodily forward on the base. The tendency of a wall to slide forward must be resisted by a force equal to the earth thrust against it and opposed to it in direction. In case the foundation bed is a solid material as rock, grooves or keyways can be cut in the foundation which will be filled with concrete when the concrete is placed, thus making a surface on the base which will prevent sliding. When the foundation is earth or gravel it is necessasry to depend upon the friction between the base of the wall and foundation to resist the sliding. This friction is dependent upon the weight of the wall and the weight of the earth on the heel and the coefficient of friction between the concrete and earth. To obtain the length of heel (A) required to get the necessary weight

$$T = \mu P = \mu (W + Aw)$$

or

$$A = \frac{\frac{T}{\mu} - W}{w} \qquad \ldots\ldots\ldots\ldots (1)$$

The downward pressure caused by the friction in the plane aa' is neglected but would increase P when the wall tends to overturn. If a key be made below the base, the earth in front of the key would have to be pushed along with the wall if it should slide forward, thus producing friction of earth on earth instead of earth on concrete, the coefficient of friction of which is less. Moreover the adhesion of the earth in its natural state exerts an additional resistance against sliding and the key would prevent a film of water from collecting between the wall and foundation and acting as a lubricant. Also the earth in front of the wall produces a resistance against sliding, but is often neglected.

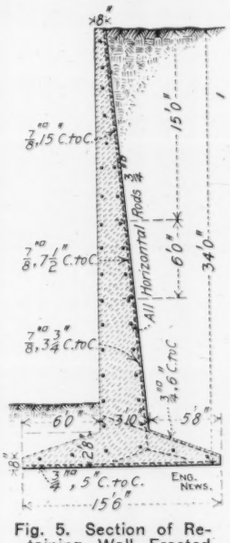

Fig. 5. Section of Retaining Wall Erected by Pennsylvania R. R. at Torrence Road Station, Cincinnati, O.

The tendency of a wall to fail by sliding might be compared to the shearing stress in a cantilever beam and the tendency of a wall to fail by overturning to the stresses in a cantilever beam caused by the bending moment, where the pressure under the toe is like the compressive stress in a beam and the weight of the wall and backing takes the place of the tension in the beam. See Fig. 1.

The earth thrust being considered to act at one-third of the height of the wall from the bottom, the overturning moment (M) will be

$$M = T \times \frac{H}{3}$$

This overturning moment must be balanced by a resisting moment of equal value. The two forces of the couple which gives this resisting moment are shown as P_1 and P_2 (Fig. 1) and are each equal to the weight of the wall plus earth on heel. P_1 acts through the center of gravity of the wall and backing and P_2 through the center of gravity of the polygon mno. As the plane ma is incapable of resisting tension, the area of the polygon mno represents the upward reaction which the foundation exerts on the bottom of the wall. The unit pressure is maximum (s) under the end of the toe and decreases to zero at n. For a wall of given weight and length of heel with a given overturning moment acting against it, P_2 will take such a position as to give y the proper value to satisfy the equation

$$M = Py \qquad (2)$$

because the resisting moment, Py, must equal the overturning moment, M. As P_2 is the resultant of the upward reactions along the base, one-half of the area of mno must lie on each side of the line of action of P_2. In order that s will not be greater than the bearing power of the earth, the toe must be extended far enough in front of P_2 to

distribute the reaction. The total length of the base, from the Fig. 1 is

$$b = J + y + L \qquad (3)$$

the values of J, y, and L being found as follows: L, the distance of the center of gravity from the back end of the heel can be found by taking moments about a, to be

$$L = \frac{W(z + A) + \frac{wA^2}{2}}{P} = \frac{2W(z + A) + wA^2}{2P} \qquad (4)$$

P, the total weight of wall and earth on the heel, is

$$P = W + wA \qquad (5)$$

If the friction in the plane aa' ($F = \mu' T$), is considered, P will be

$$P = W + wA + \mu' T \qquad (5a)$$

From equation (2), y can be found to be

$$y = \frac{M}{P} \qquad (6)$$

If mno is a triangle the distance of its center of gravity from the end of the toe (m) is one-third of the length of the base (x) of the triangle, or

$$J = \frac{x}{3} \qquad (7)$$

The area of mno must be P, so

$$\frac{xs_1}{2} = P \text{ or } \frac{x}{3} = \frac{2P}{3s_1}$$

From (7) $$J = \frac{2P}{3s_1} \qquad (8)$$

Inserting in equation (3) the values found in equations 4, 6 and 8,

$$b = \frac{2P}{3s_1} + \frac{M}{P} + \frac{2W(z + A) + wA^2}{2P} \qquad (9)$$

Formulas (1) and (9) give the proper length of base and heel that should be given a retaining wall. It will be seen that for a wall of given height acting under a given earth thrust, the length of base depends upon the bearing power of the foundation bed, the total weight of wall and backing and the length of heel.

FACTORS OF SAFETY.

The problem in design to prevent internal failure is to make the reinforced concrete beams composing the heel, the toe, and the upright portion of the wall (which might be called the trunk) of sufficient size to resist the stresses. These are simply cantilever beams and may be figured for the bending moment acting on them by the customary method used for reinforced concrete beams. The bending moment on the trunk of the wall is caused by the earth thrust, the resultant of which is considered to act at a point one-third of the height from the bottom. The moment would then be one-third of the height times the thrust. There seem not to be many experimental data regarding earth thrust against retaining walls, but what there are indicate that the actual earth thrust of a backing of a certain angle of repose and a certain weight is about one-half of that calculated by the customary formulas, as Rankine's. This actual thrust may be called the normal thrust as distinguished from such abnormal thrusts as those due to freezing, etc.

The bending moment in the toe is caused by the upward reaction of the earth acting against the toe. This force is represented (Fig. 1) by the part of the triangle mno directly under the toe.

The bending moment in the heel is caused by the weight of the earth resting upon it, the force due to friction in the plane aa' and the upward reaction of the earth, if any, under the heel acting negatively. This reaction is represented by the part of the polygon mno directly under the heel.

An analysis of the stresses in the various members should be made to get at the factors of safety. The total factor of safety not only provides for the abnormal pressures to which retaining walls may be subject, as hydrostatic pressure or a thrust due to freezing, but also for uncertainties of the materials. The fact that the actual ultimate strength of the materials will probably not agree with the assumed values is accounted for by the "factor of ignorance," which is one element of the total factor of safety. But if the actual value of P_1 differs from its assumed value, the neutral axis (n) will have a different position along the base from that for which the calculations were made and the stresses in the heel and toe may be altogether differently distributed. This complicates the determination of the factor of safety.

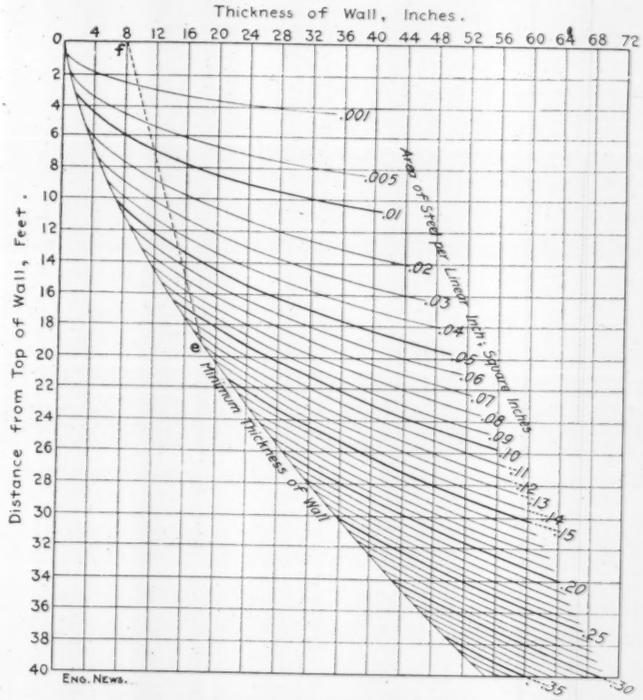
Thickness of Wall, Inches.
Distance from Top of Wall, Feet.
Area of Steel per Linear Inch, Square Inches
Minimum Thickness of Wall
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FIG. 6. SHOWING THE DEPTH OF WALL REQUIRED FOR DIFFERENT HEIGHTS AND THE QUANTITY OF REINFORCEMENT FOR WALL OF ANY THICKNESS AT ANY DISTANCE FROM THE TOP.

This is illustrated by Fig. 2. Let the value of P_1 be represented by aP_1 and the ultimate thrust by aT. Then the resultant pressure would be aR and the reaction polygon mno. Now suppose P_1 be increased slightly to $a'P'_1$. The resultant would be $a'R'$ and the reaction polygon $mn'o'$. The moment in the toe is greater in the first case because the entire polygon mno is directly under the toe while in the second case only part of the polygon $mn'o'$ is directly under the toe and the total area of $mn'o'$ is but slightly greater than mno. Also the moment arm is greater in the first case. Neglecting the weight of the wall acting directly on the foundation the moment in the trunk must be equal to the sum of the moments in the heel and toe at their junctures. As the moment in the trunk is the same in both cases, the moment in the heel increases as the moment in the toe decreases. Thus, it may be seen that the moments in the heel and toe are not maximum at the same time and that a slight variation in P_1 may cause a very much greater variation of stresses in the heel and toe.

The uncertainty in the value of P might be adequately covered by a factor of ignorance in the part it plays toward overturning or sliding; but owing to its effect on the stresses in the base, the heel and toe should be given a larger factor than the other parts of the structure. That is, more unutilized material is required in the base because the maximum stress might be in one part or in another, but at each place where it might occur there should be enough material to obtain the desired safety margin. It would be difficult to judge what factor of safety should be given the heel and toe to make their chance of failure the same as that of the other parts. Therefore, it is best to fix the possible or probable limits which P_1 may have and to determine the maximum stresses in heel and toe when P_1 varies between these limits. The value of P_1 is also very uncertain because it is partly dependent on the resistance to sliding (F) in the plane aa' and this may be small or it may be very great, due to cohesion of the earth backing. The value of the limits of P_1 may be taken when F is zero and when F is maximum. There is no data by which the maximum value of F could be assumed with any degree of accuracy, but its maximum effective value can be found as shown in the following paragraph.

Having determined on the ultimate resisting moment of the trunk, the maximum overturning moment which the wall will stand before the failure of the trunk is known. It will be well, then, to assume such a value for F that will produce a resisting moment to overturning equal to the maximum overturning moment and which will also produce a maximum bending moment in the heel. To get this value, reference is made to Fig. 3. The overturning moment is

$$M = y_1(W + wA) + y_2 F \qquad (10)$$

Now as long as the neutral axis is at a point along the base, the force (F) acts downward as shown because the end of the heel tends to move upward and push the earth directly above it. As F increases n moves backward until it reaches the end of the heel. Here the end of the heel ceases to move upward, the wall simply tending to revolve about it, so F ceases to act. Just before this occurs F has its maximum value and the forces will have positions as shown in Fig. 3, where

$$y_1 = \frac{2b}{3} - L_1 \text{ and } y_2 = \frac{2b}{3}$$

Equation (10) becomes

$$M = \left(\frac{2b}{3} - L_1\right)(W + wA) + \frac{2b}{3} F \qquad (10a)$$

and

$$F = \frac{M - \left(\frac{2b}{3} - L_1\right)(W + wA)}{\frac{2b}{3}} \qquad (11)$$

We have now indicated how to determine the shape and size of a reinforced concrete retaining wall to obtain stability. To prevent sliding on the base, the heel must be made long enough to get sufficient weight of earth upon it. To prevent overturning, the base is made broad enough so that the earth under the toe will not crush. To get the broad base with a given heel, the toe is prolonged. To prevent internal failure, the reinforced concrete beams are made strong enough to resist the tension, compression and shear.

It is not necessary, of course, to make the heel just long enough to resist sliding. It may be made longer if desirable, but this is usually not best. For example, in most cases a long heel and short toe mean more excavation than a shorter heel and longer toe because the ground is usually higher back of the wall. Also, when a wall is built on a foundation bed which is liable

to settlement, a short heel causes P_1 to strike the base further toward the back, bringing the resultant near the middle of the base, under normal earth thrusts. This makes a uniform pressure on the earth all along the base and the settlement is uniform. If the resistance to sliding on the base is produced by keys or the like, the necessary length of heel is not determined by the friction required and may be made less; but as the heel is changed in length the total length of base required is changed. The curves given in Fig. 7 show the lengths of base required to produce the same stability to overturning for different lengths of heel. It will be seen that within certain limits the base is of practically the same length. It is best to make the heel of such a length as will keep the length of base within these limits.

There is another factor which might determine the ratio of the lengths of heel to toe and that is the economy of material; but more important things usually determine this ratio and this will not be discussed further than to state that the greatest economy of material needed to construct the footing is obtained when the maximum moments in the heel and toe are about equal or when the moment in the toe is a little greater than the moment in the heel.

The question of settlement was mentioned above, and it might be well to call attention to the fact that this is probably the most serious problem in retaining wall construction. Nearly all the failures of retaining walls seem to be due to the settlement of the earth under the toe. In most structures, as in buildings, the settlement is uniform and settlements of several inches or a foot may be allowed for; but in a retaining wall, the settlement being under the toe, the wall is thrown out of plumb, moving the center of gravity further forward and bringing still more pressure under the toe, causing more settlement and so on. In a gravity wall, the pressure under the toe varies about with the height; and if the designer finds that he must build his wall on a soft foundation bed, liable to settlement, he can help matters but little (except by using expensive piling) and makes essentially the same design that he would for a solid rock foundation. As has been shown the reinforced wall can be made to correspond to the foundation bed on which it is to be built.

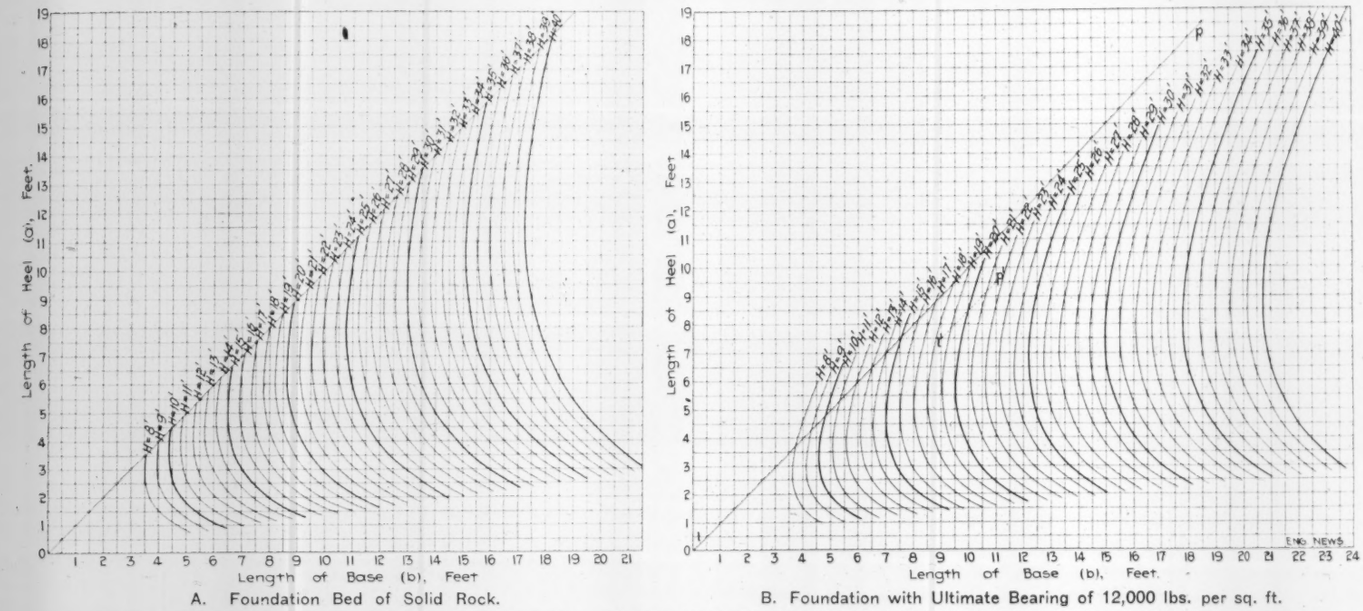
In using the above formulas in cases involving settlement, s_1 (the ultimate bearing power of the earth) should not be taken as the pressure per square foot which would actually crush the earth, but should be taken as the pressure per square foot which would cause the maximum settlement permisssible.

CHARTS FOR DESIGNING RETAINING WALLS.

The accompanying table and charts were figured from the above formulas for the most usual case. The earth thrust was taken for a backing of 100 lbs. per cu. ft. with an angle of repose of 34° (1½ to 1) and without surcharge. A factor of safety of four over the maximum normal thrust (one-half the calculated value by Rankine's Formula) was taken for the external forces. This is large for retaining walls and gives a wall strong enough for the heaviest traffic, as along railroads or for a backing whose properties approach those of a fluid. The friction in the plane aa' was neglected in figuring external forces. A factor of six over the maximum normal thrust was taken in figuring the internal stresses of the trunk. One reason for giving this a greater factor of safety than the external forces is that the trunk may be subject to a pressure due to a collection of a thin column of water just back of it or to freezing; but these forces produce a greater friction in the plane aa', which resists overturning and the tendency to slide on the base is resisted by friction on both sides of the heel. The ultimate strength of the concrete in compression was taken as 2,000 lbs. per sq. in. For the quantity of steel 0.7% of the area of the cross section of the beam was used. Since some recent failures of reinforced concrete buildings a larger percentage of steel has been advocated by some engineers. But as the weak part in a reinforced concrete beam is the concrete, due to careless workmanship in the field, it would seem more important to increase the quantity of concrete than steel. So a large factor of safety was used and not such a large percentage of steel. Any other percentage can be used, however, without otherwise changing the charts.

Fig. 6 shows the minimum or theoretical thickness of wall for any distance from the top and also the amount of steel required at any distance from the top for any thickness of wall. The accompanying table shows the length of heel required for different heights of wall (Equation 1), for $\mu = .67$ and $\mu = .8$.

For $\mu = .67$ the thrust can be resisted entirely by the friction on the base. However, when there is much solid earth in front of the wall, the results obtained with $\mu = .8$ should be large enough. Fig. 7 gives the different lengths of base required for walls of different heights and of different lengths of heel (Equation 9). Fig. 7 (A) is for a wall built on solid rock and Fig. 7 (B) for a wall built on earth having an ultimate bearing power of 12,000 lbs. per sq. ft., as clay or sand. Fig. 8 gives the minimum thickness of heel and toe and the amount of steel per linear inch of wall for any thickness. The dimensions for the heel and toe were determined from the maximum moments which might act in each. To get the maximum forces acting against the toe for a given wall, the value of the friction is the plane aa', was considered as being equal to zero and the curves for the dimensions of the toe calculated and drawn accordingly. To get the maximum forces acting against the heel the value of P_1 was taken as maximum, the maximum effective value of F being determined by equation 11. These curves for the heel are empirical, but in practical cases agree closely with the calculated values. The part on the left-hand side shows the toe. Knowing the total weight of wall and backing (P) and the bearing power of the earth, the correspondingly marked curve gives the minimum thickness of toe at any distance from the front end. To find the quantity of steel required for a certain thickness of toe for a certain distance from the end, take the point on the minimum thickness curve the same distance from the end and follow the line horizontally to the line cd in the middle part of the chart; then follow the curved line until a point is reached which has an ordinate equal to the actual thickness of the toe. The abscissa of this point will represent the area of steel required. The curves on the right-hand part of the chart give the minimum thickness of heel at different



A. Foundation Bed of Solid Rock. B. Foundation with Ultimate Bearing of 12,000 lbs. per sq. ft.

FIG. 7. CHARTS SHOWING LENGTH OF BASE REQUIRED FOR DIFFERENT LENGTHS OF HEEL AND DIFFERENT HEIGHTS OF WALL.

TABLE GIVING LENGTH OF HEEL (A) REQUIRED TO PREVENT SLIDING FORWARD ON THE BASE.

Height of Wall (H).	Length of Heel (A)	
	$\mu = .67$.	$\mu = .80$.
ft.	ft.	ft.
8	2.9	2.3
9	3.2	2.6
10	3.5	2.8
11	3.8	3.0
12	4.1	3.3
13	4.5	3.5
14	4.7	3.7
15	5.0	4.0
16	5.3	4.2
17	5.6	4.4
18	5.9	4.6
19	6.1	4.8
20	6.4	5.0
21	6.7	5.2
22	7.0	5.4
23	7.2	5.6
24	7.5	5.8
25	7.8	6.0
26	8.1	6.2
27	8.3	6.4
28	8.6	6.6
29	8.9	6.8
30	9.1	7.0
31	9.4	7.2
32	9.6	7.4
33	9.8	7.5
34	10.1	7.7
35	10.3	7.8
36	10.5	8.0
37	10.7	8.1
38	11.0	8.3
39	11.2	8.5
40	11.4	8.6

heights of wall. The quantity of reinforcement for the heel can be found from the middle part of the chart in the same way as for the toe.

To explain the charts more fully; take an example of a wall 20 ft. high, built on a clay foundation with ultimate bearing power of 12,000 lbs. per sq. ft. From Table I. it is seen that with $\mu = .8$ the heel for a wall 20 ft. high must be 5 ft. long. Referring to the right-hand side of Fig. 8, the depth of heel is found from the curve, $H = 20$ ft. at a point (g) 5 ft. from the end of the heel to be nearly 14 in. Suppose it is desired to taper the heel to a thickness of 8 in. at the end. The line gh will represent the thickness at all points. To get the reinforcement, follow the horizontal line from g to k in the line cd in the middle of the chart. As at this point the minimum or theoretical thickness of the beam is identical with the actual thickness, k represents the amount of reinforcement, which can be read at the bottom of the chart to be nearly 0.10 sq. in. per linear inch. Using ¾ in. square rods, this requires a spacing of 5½ ins., c. to c.

As the heel is 14 ins. thick the length of the trunk will be 14 ins. less than 20 ft. or nearly 19 ft. From Fig. 6 the required thickness of the trunk for 19 ft. is about 18 in. Making the wall 8 ins. thick at the top, the line ef represents the thickness of the trunk at all points. From the reinforcement curves it is seen that about 0.13 sq. in. per linear in. of steel is required at the juncture of the trunk to the base. If ¾-in. sq. rods are used, this means a spacing of 4¼ in. c .to c.

Further up in the wall the quantity of steel may be decreased, and so it is not necessary to carry all of the rods all of the way up. Suppose it is desired to drop out one rod in four. This will leave an average spacing of 5.7 in. and a quantity of 0.10 sq. in. The point at which this may be done is found by the intersection of ef with the reinforcement curve marked 0.10 sq. in. to be 17.3 ft. from the top. The points at which each of the remaining two rods in four may be dropped out can be found in the same way. Care should be taken to always immerse the rods a sufficient distance to develop their strength.

To get the length of base reference is made to Fig. 7 (B). For the curve representing $H = 20$ ft. and for a length of heel of 5 ft. the total length of base is 9.6 ft. The heel 5 ft. long and the trunk 18 in. or 1.5 ft. thick leave 3.1 ft. for the length of the toe. The total weight of wall and backing (P) can now be approximately computed to be 14,000 lbs. From the left hand side of Fig. 8 it will be found that the thickness of the toe for $P = 14{,}000$ at 3.1 ft. from the end must be about 10 in. (interpolating between $P = 10{,}000$ and $P = 20{,}000$).

In construction it is convenient to have the heel and toe the same thickness at the juncture with the trunk. Then the toe will have a thickness of 14 ins. as shown at f, Fig. 8, and giving it a thickness of 8 in. at the end, the thickness of all parts would be represented by the line fi. To get the amount of reinforcement at a distance of 3.1 ft. from the end, start at the point f', which represents the theoretical or minimum thickness of the toe at 3.1 ft. from the end and follow the line of 8 in. to the point k' in the line cd. Then follow the curve intercepted, until the actual thickness of the toe is reached. This point l gives the required reinforcement which is 0.05 sq. in. per linear in. Using ⅝-in. sq. rods, this requires a spacing of 7¾ in. The required reinforcement for any point in the heel or toe can be found in the same way.

Fig. 4 gives a cross section of the wall just calculated. It might be of interest to note that with a normal earth thrust against this wall and neglecting friction in the back, the resultant will strike the base in the middle and the pressure on the foundation will be uniform.

Sometimes the location is such that it is impossible to make a toe. To get the length of base in this case, draw a line $l'p'$ [Fig. 7 (B)] to the right of and parallel to lp, the horizontal distance between the two being equal to the thickness of the trunk at the base. The intersection of $l'p'$ with the curve will give the length of base. Thus in the 20 ft. wall $l'p'$ intersects the curve for $H = 20$ ft. at a point which gives the length of heel as 8.5 ft. and the total length of base as 10 ft.

Fig. 5 shows the cross section of a wall recently erected by the Pennsylvania R. R. Co. It is much higher than the example given above, and although for slightly different data, than those to which the accompanying charts apply, illustrates well the dimensions required for a wall of such a height.

It is often found handy to have the wall large enough to let a man get inside of the forms. Then the wall might be made 12 in. thick at the top and reinforced accordingly. Such details in design, although they may require more concrete, often make the construction cheaper.

Retaining walls are often built in places where it is necessary to contend with running water and springs. In cases of this kind it is well to use a surplus of concrete in the footing.

WALLS WITH COUNTERFORTS.

The foregoing discussion has been confined to a wall having an inverted T-shaped cross section, but the same principles for the external stresses can be applied to the counterfort wall. As to the internal stresses, each force must be carried from its point of application to the counterforts or ribs by means of longitudinal reinforcement. This results in a slab construction in the face and floor of the wall. The slabs will be subject to amazingly different stresses under different loads which may come upon the retaining wall. The pressures against the floor may be distributed evenly over the slab or they may be concentrated in one part, depending upon a narrow strip of the slab to resist a force equal to the entire weight on the wall for the entire panel length. This necessitates the use of a large quantity of idle material. Many counterfort walls have been designed, apparently, for only one load, resulting in a wall which will not be safe under other loads and loads which are just as liable to come upon it as the assumed load.

This handicaps a good kind of construction, for the layman who sees one reinforced wall fail, naturally concludes that they all may fail. Moreover, a reinforced structure of this kind acts as a monolith on the whole and the positions of the tensile stresses must be determined for all of the different loadings. For example, the slabs act as continous beams and not as simple beams. At the juncture of the floor and face there is also a continuity which produces stresses at right angles to the longitudinal stresses. These require, besides the longitudinal rods on each side of the slab at proper places, a vertical and horizontal system of rods at right angles to the longitudinal rods. If all of these stresses are not provided for, dangerous or at least disfiguring cracks will occur. Also, the shearing stresses must be provided for and resisted, while in a T-wall, using cantilever beams, the shear is always taken care of in providing for the bending moment.

However, with sufficient care a good counterfort wall can be designed, and with a saving of concrete over a T-wall. Such a saving of concrete, though, does not impress the contractor as it may the designer. Besides the network of rods in all directions to be put in place and kept in place, the forms for a counterfort wall are much more costly than for a T-wall. The forms for a counterfort wall have actually been known to cost the contractor more than the concrete put into them. The forms for a T-wall cost no more than those for an unreinforced wall of the same height. The relative cost of forms and concrete varies somewhat in different localities where the cost of material is different and this point is best shown not by discussion but by competitive bidding in each case.

It should be borne in mind in designing reinforced concrete retaining walls, that, although the great saving is made by using earth as a weight instead of concrete, retaining wall construction is different from floor construction in that the weight of the beam itself is an aid to stability. Thus the decreased dead load obtained by slab construction does not give the advantage to retaining walls that it does to floors of buildings or bridges. Also, the greatest pressure against the trunk is next to its juncture to the base. This is adapted readily to cantilevers and, in fact, vertical rods must be placed in the back

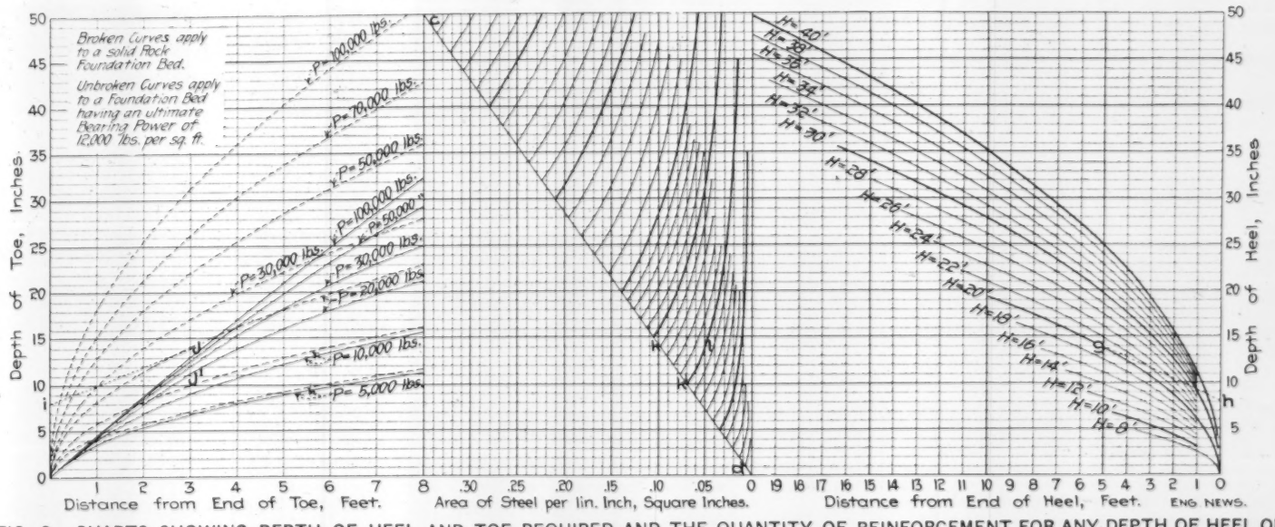


FIG. 8. CHARTS SHOWING DEPTH OF HEEL AND TOE REQUIRED AND THE QUANTITY OF REINFORCEMENT FOR ANY DEPTH OF HEEL OR TOE AT ANY DISTANCE FROM THE ENDS.

of the curtain or slab for some distance up even if counterforts are used. In cases of the settlement of the foundation bed, the advantage of the reinforced toe should not be overlooked. But, above all, whatever the type of wall, the various stresses under different loads must be provided for.

EARTH DAM OF THE SUGAR LOAF RESERVOIR IN COLORADO.*

By R. M. HOSEA.†

The Sugar Loaf reservoir, owned and operated by the Colorado Fuel & Iron Co., is located about five miles west of Leadville, in Lake Park, on the Lake Fork of the Arkansas River. It occupies the bed of an ancient lake at the base of Sugar Loaf mountain. The mountain slopes are well timbered with second-growth spruce, pine and balsam, and have a grassy flower-covered carpet, on which the winter snows lie until late in the year. The lake elevation is about 10,000 ft. above sea, and in consequence the melting snows do not begin to run off in any considerable volume until June. The drainage area reaches back to the summits of high mountains 14,000 ft. or more in elevation, and on which in the gulches and timbered slopes much of the snow lies all the year through.

The Sugar Loaf reservoir forms part of the system of water supply for the Minnequa Works at Pueblo, which demand large volumes of water in the various processes of steel making. Most of this water is used for cooling purposes, at blast furnaces and in condensing engines, where it is raised in temperature and then returned to the stream, thus being available for re-use below.

The laws of Colorado provide for the storage of flood waters in reservoirs in times of plenty, which returned to the streams at later periods may be withdrawn at points many miles below in ditches, pipes or conduits, less a fixed discount for loss by evaporation and seepage. The channels of the streams are thus used as carrying conduits, the process being under the direction of the State Engineer and his Water Commissioners, who fix the amount of deduction to be made from their observations and gagings of the stream in question.

The contract was let, material delivered and work begun in 1902. The season was so far advanced, however, that it was impossible to complete the work before winter, as at the altitude (nearly 10,000 feet above sea level) the snows begin in October and frost forms. However, the base of dam was nearly completed and much of the preliminary work done. The work was resumed the following spring as soon as the frost was out of the ground and finished in September, 1903. In the following winter and spring water was stored under direction of Prof. L. G. Carpenter, then State Engineer, and the reservoirs nearly filled. This water was withdrawn, or nearly so, the following fall and winter (as some slight seepage had developed beneath the dam) in order to give opportunity for settlement and consolidation of the prism of the dam and the permeable material below its base. Such alternate raising and lowering of the water level has since been carried out each season. The dam impounds 30 ft. of water, and there is ample spillway area at the north end, with an emergency spillway at the south end.

The average annual rainfall at Leadville is 14 ins., as shown by U. S. Government observations, and the drainage area of the Sugar Loaf reservoir is from 25 to 30 sq. miles, as determined by the topographic atlas sheets of the U. S. Geological Survey. It is probable that observations on the above drainage area would show a considerably higher precipitation. Being on the west side of the valley, more and deeper snows fall in winter and more frequent rains occur in summer; this is a matter of local observation.

The run-off as determined by the gagings of the Lake Fork shown in U. S. Geological Survey reports, 1891-92, and the gagings taken by the Colorado Fuel & Iron Co. during the two seasons of survey and construction, show a discharge in the Lake Fork of the Arkansas River ample to fill the reservoirs built and proposed at least once each season. The maximum flow observed is some 600 second-ft. in June; the minimum 6 second-ft. in October, continuing until snow begin to melt in the following May.

Cloudbursts (so called) at this altitude and on the slopes of what may be called a secondary range of mountains protected from the direct meeting of mountain and plains air currents, are unlikely, but the location of this reservoir is such that immense damage would be done below it in case the dam were overtopped and carried out. Therefore, extreme figures have been used in providing outlet for the water in the outlet basin, and the spillways at the two ends of dam.

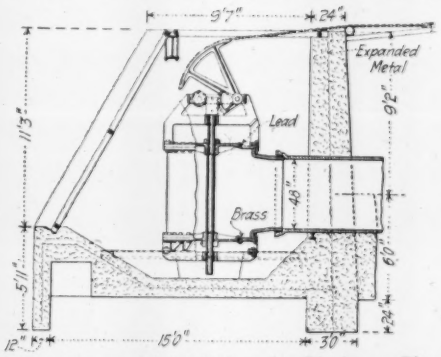


Fig. 2. Balanced Inlet Valves for Discharge Pipes: Sugar Loaf Dam.

Surveys of the flooded area, section lines, dam sites, etc., were made. A careful contouring of the flooded area for each 5 ft. depth followed, and calculation of capacity for each 1 ft. depth by interpolation was made as required by State laws. As all surveys were referred to a base line and the method of latitudes and departures was used, it was possible by using prismodial formula to get capacities for each foot of depth to within a limit of error of 1%. Test pits at numerous points in the flooded area and at the dam site and a study of the locality disclosed the following:

1. The valley was originally closed by a moraine or glacial deposit of clay and boulders through which the stream had broken. 2. The reservoir site was an ancient lake bed, underlain wholly or partially by a clay sheet 4 ft. or more thick, which extends partially under the proposed dam. 3. The material in the moraine and on the hillsides and in the vicinity generally was a clay, sand and boulder mixture, extremely favorable for dam construction.

Borings at the outer or lower half of the dam showed the stream bed here to have an underlying deposit of fine sand of unknown depth, and indicated that the clay sheet should not be penetrated by any sheet piling or core wall construction in the body of the dam, but rather favored the making of a juncture with the clay sheet below by a clay lining of sufficient thickness and suitable construction placed upon the inner or water face of the dam.

The entire area of the dam site was overgrown with willows and some trees, and in the lowest portion, adjoining the stream, covered with 1 to 2 ft. of black muck. All this had to be removed, roots grubbed out and top or vegetable soil skimmed off. The latter was done by a light plowing and handling with slips. The surface was then benched or furrowed. The channel of the stream was diverted to one side and excavation made for the pipe cradle or concrete base for the outlet pipes. The north part of the dam was built first, and extended as far as feasible towards the gap at the south end in the following manner: Adjacent to the Colorado Midland Ry. the spillways were excavated and this material, exclusive of large boulders, was placed in the outer part of the dam section. Borrow pits were laid out on the inside of the reservoir site over a large area and stripped of all vegetable matter, exposing the clay-sand mixture (containing some boulders), and beneath which was the 4-ft. clay sheet. The dam then was carried up in thin layers by depositing the clay on the inside face to a thickness of 20 ft.; then the next best material, and so on to the outside, where the poorest material was used. The whole was smoothed, sprinkled and rolled with a heavy Springfield roller, blending all together, the formation of layers being carefully avoided by depositing loads irregularly.

After the base of the dam was built, it was found best both for economic results and speed to have the contractors install a small steam shovel and load into dump wagons. Grading machines were tried for a time, but the presence of boulders in borrow pits made their use inadvisable, and it was found most economical to load direct from the dipper of the steam shovel into dump wagons, which, with a little care, was done without undue wear and tear on the wagons. The cross-section (Fig. 1) shows the manner in which the different materials were blended together to form the dam prism. The filling in around the pipe and cross-walls was done by hand, tamping and puddling with water, and using the best clay material from the borrow pits. This was of a grade that might be termed potter's clay, very fine, and when wetted and worked made a splendid puddle.

Pipe Cradle.—This excavation was first stripped of vegetable matter, roots and muck and the underlying clay sheet exposed to a point about the center of the dam, where it thins out into sand of unknown depth. The trenches for five cut-off or cross-walls, about 21 ft. apart, were excavated 2 ft. deeper and wider than the balance of excavation, to more effectually check any flow of water along the surface of the concrete. The base consists of 48 ins. of concrete composed of the most compact mass that could be made with the sand, gravel and small boulders existing in the vicinity of the site, determined by experiment for each kind of aggregate used. For part of the work slag from the silver-lead smelters at Leadville was used instead of gravel or broken stone, but was not as satisfactory as the gravel. Both sand and gravel were from granitic formations and excellent in quality, although the sand was rather fine grained. Embedded in the base were seven lines of 85-lb. steel rails, placed about 3 ft. apart, and cross rails 6 ft. apart finished the upper surface. On this three lines of 48-in. extra heavy cast-iron pipe with lead calked joints were laid, 7 ft. c. to c., on a grade of 0.5% sloping to the outlet basin. The pipes were then bedded between and at the outside in well-tamped concrete to the level of the center of the pipes and the top surface left quite rough and irregular. The cross-walls were brought up 4 ft. above the tops of the pipes and projecting 2 ft. beyond the sides of the excavation into the solid ground. After removal of the forms, puddling clay was tamped by hand above and around the structure for 4 or 5 ft. and blended with the next best material, as described in the general construction of the dam.

Inlet Basin and Valves.—At the toe of the inner or water face of the dam a concrete basin was constructed (Fig. 2), consisting of a back retaining wall in which the three lines of 48-in. pipe were embedded, and two wing or side walls with a concrete bottom. The back wall forms part of the concrete cradle supporting the pipes and extends below it to form a cut-off wall, and in the same manner the front wall and wings are placed well into the clay to cut off any water flow from the 30-ft. head when the reservoir is filled. The front and top of the basin are covered with a screen of iron bars to keep out drift or large fish. The front bars rest on an iron base and interlock and are bolted through with top horizontal bars, the whole resting on a transverse I-beam, which is embedded in the concrete side walls at its ends. The bars thus present a smooth surface at front and top from which drift and trash can be readily raked when submerged. The front, side and back walls and the concrete bottom are reinforced with one or more sheets of No. 10, 3½-in. expanded metal.

Supported on 85-lb. rails resting on piers in the bottom of the inlet basin, are three cast-iron balanced valves in T form attached by lead-calked joints to the bell ends of the 48-in. pipe lines projecting through the back wall, as shown in Fig. 2. Each valve has an upper and lower brass-lined disk horizontally mounted on a

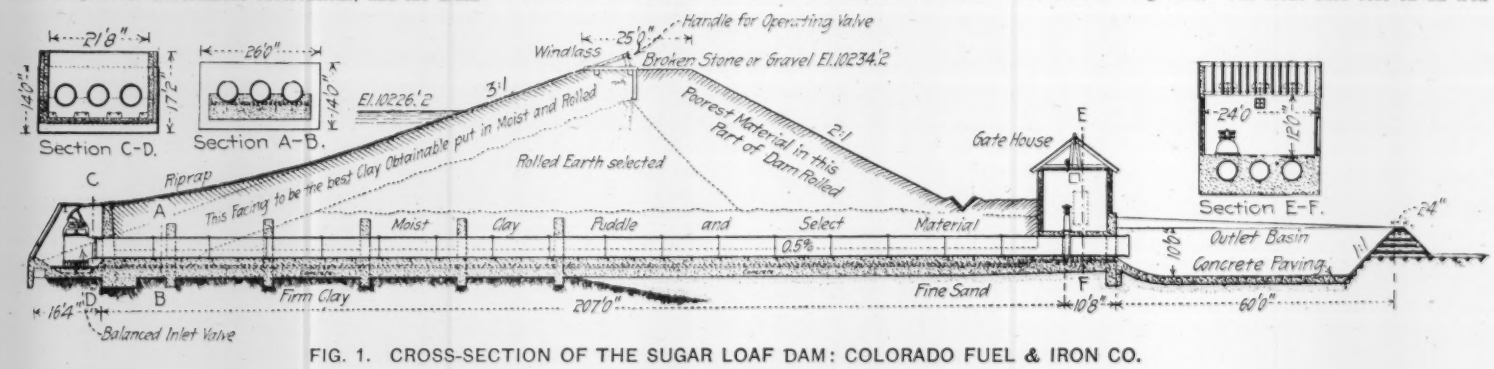


FIG. 1. CROSS-SECTION OF THE SUGAR LOAF DAM: COLORADO FUEL & IRON CO.
R. M. Hosea, Chief Engineer.

*Abstract of a paper presented before the Western Society of Engineers, Chicago, on April 3, 1907.

†Chief Engineer, Colorado Fuel & Iron Co., Denver, Colo.

brass-bushed shaft; these seat on lead-lined brass conical bearings and are operated by a rack and pinion movement to the shaft by means of a sector with grooved rim, carrying a chain which passes between the bars of grating and extends along the slope to the top of dam, as shown in Fig. 1. At this point it is operated by a screw and two-handled nut abutting against a strong wooden frame anchored in the ground.

The motion of the sector is entirely below the bars of grating and the chain is protected in a trough or groove formed in the riprap face of dam on the 3 to 1 slope which flattens out to meet the top of the back retaining wall of the inlet basin. In this way the valves can be operated without interference from ice or drift or the necessity of a valve tower in the reservoir. The upper and lower disks of these valves are so proportioned that they tend to remain closed at ordinary stages of water, but are normally held open by the chains, the regulation of water outflow being controlled by three Rensselaer geared valves placed at the lower side of the dam next the outlet basin. The inlet valves were designed by the engineering department of the company from suggestions made by Mr. Gordon Land, an irrigation engineer of large experience in such work. They have been used with success under similar conditions on several other reservoirs constructed under the writer's direction.

Outlet Basin and Valves.—Outside the lower face of the dam, as shown by the sectional view, are placed three Rensselaer geared valves for controlling the outflow. They are enclosed in a concrete valve house with corrugated iron roof built over and resting on the concrete pipe cradle. The walls were built in forms, using one sheet of No. 10, 3½-in. expanded metal in them, and a cement ceiling was constructed attached to a netting of light expanded metal fastened to the under sides of ceiling joists with 10d. nails or staples. Nails were driven into the sides of joists about 12 ins. apart and the 3-in. ceiling formed around them and between the joists, embedding the netting ½-in. in the under face. A heavy block resting on the joist carrying a ring bolt over each valve and extending through the ceiling serves as an attachment for chain block should it become necessary to take down a valve for repairs. In such an event the upper balanced valves would easily shut off the water from any line of pipe.

This style of construction of valve house was adopted as being better and cheaper than brick work in that locality and to protect the valves against freezing in the cold weather of this altitude, about 10,000 ft. above sea level. Provision is made also for setting a stove, and banking around valves with saw dust, etc., if necessary in extreme cases. To further guard against frost the outlet basin is constructed as shown by Fig. 1, with a concrete lined bottom and three sides of log cribbing filled with rock and sand and double boarded with burnettized plank, with a calked oakum joint where it abuts against the end wall of the pipe cradle. This construction maintains a water cover of 2 ft. over the ends of the outlet pipes at all times and prevents frost from entering the ends of pipes and reaching the valves. The basin serves also to retain the fish and to spread the outflow of water into a thin sheet falling over the three sides of the basing to the apron outside; thence it can run quietly to the stream below.

Riprap.—The boulders from spillway and borrow pit excavation and from the slopes of the adjoining hills were hauled to the dam and the riprap facing or paving carried along concurrently with the progress of the dam. The amount and quality of this work is of prime importance at this locality, as there is a long exposure, about 1½ miles, for wave formation and the formation of ice on a full reservoir in winter is considerable. Owing to the sheltered locality, however, and the direction of prevailing winds the wave action is not so great as might be expected. The ice forms sometimes over 36 ins. thick, but usually melts quietly and thus far shows little tendency to dislodge the paving.

The riprap is laid in three zones, a lower one resting on a base at toe of slope with maximum and minimum thickness of 15 ins. and 10 ins.; a middle zone with maximum 12 ins. and minimum 8 ins. extending to the flow line; and an upper zone with maximum 6 ins. and minimum 4 ins., to top of dam. These merely indicate the quantities that were paid for, as the material composing the riprap is glacial boulders and fragments of broken boulders and the actual thickness as laid is greater. The boulders were laid to a fairly smooth top surface, supported on smaller stones where necessary and chinked with spalls, with the sides running the long way of the dam and ends breaking joints on the slope.

Spillways.—The greatest known flow of the river is about 600 sec.-ft. during the season of melting snow. Any theoretic length of spillway based on these facts or on an assumed rainfall and run-off would give much less capacity than that provided. The theoretic requirements guide us to a minimum, which in this case has been exceeded, and as much spillway capacity provided as a reasonable cost permitted. As the excavation for these was all used in the dam the cost was purely nominal. At the north end of the dam a favorable spot exists in ground composed of clay and boulders, where a level crest excavation 200 ft. long was made at high water level, elevation 10,226. Below the crest, a 1% grade to the surface, slopes into a natural hollow discharging below the dam. This part of the site is well grown with trees and willows which, with a rock-strewn surface, furnish ample protection from scour. To the north of and adjoining the 200 ft. an additional 100 ft. was excavated at a level 2 ft. higher, or 10,228. At the south end of the dam an excavation 100 ft. wide at the same upper elevation was also made.

The three lines of 48-in. pipe are each capable of carrying 400 cu. ft. per second when the reservoir is full, and the flooded area is 818 acres at 30-ft. depth. The top of dam is 8 ft. above high water line. From this it is seen that the three lines of pipe alone more than suffice to carry any ordinary flow, as the usual spring melting of snows produces about 350 to 400 cu. ft. per second and at such time the reservoir is being filled. Should the water from any cause rise 2 ft. above high water mark the spillway could then carry a sectional area of 400 sq. ft., and an additional 2 ft. would add 800 sq. ft. to this, or 1,200 sq. ft. in all, making a discharge capacity added to the pipes aggregating in all over 7,000 cu. ft. per second, or more than ten times the greatest known flood, and this level would still be 4 ft. below the top of dam. Such a discharge would wash out all bridges below the dam. Owing to the immense damage that would be done by overtopping the dam and its destruction of railway lines and other works below, these precautions have been taken, which may seem extravagant.

The flooded area contained considerable brush, dead and burned timber and some live trees. All the logs and brush were gathered into piles and burned during the progress of the work. The live timber or such as was needed was used in construction of outlet cribs at the dam. The bottom land flooded was covered with black soil which made the water somewhat black and offensive the first season of flooding. It has now cleared up and the water is of a deep, clear blue color, justifying the name of Turquoise Lake that has been given the reservoir by the railway, which has advertised it as a resort.

The following features of the dam may be worth recording:

		Cu. Yds.
Earth from borrow pits		96,762
Earth from spillways		17,601
Total excavation		114,363
Top soil wasted	17,475 cu. yds.	
Riprap stone from excavation	1,500 cu. yds.	18,975
Actual excavation put into dam		95,388
Actual cross section of dam		90,200
Difference		5,188

Shrinkage, 5,188/95,388 = 5.44%.

It should be noted that the dam remained partly completed through one winter and had a chance to become compacted, although it was thoroughly sprinkled and rolled during all the construction before and after this interval.

The estimated cost of the dam, including the site, lands, materials, labor and engineering, was $127,655, and the final cost was slightly within this amount. The contractors were Clough & Anderson, of Colorado Springs, Colo. The work was done under the direction of the writer as Chief Engineer; W. M. Porter, Assistant Chief Engineer; W. D. Salter, Resident Engineer, of the Engineering Department of the Colorado Fuel & Iron Co. Mr. Jno. Birkinbine, Philadelphia, was Consulting Engineer. All plans and construction were approved by the then State Engineer, A. J. McCune, and his successor in office, Prof. L. G. Carpenter.

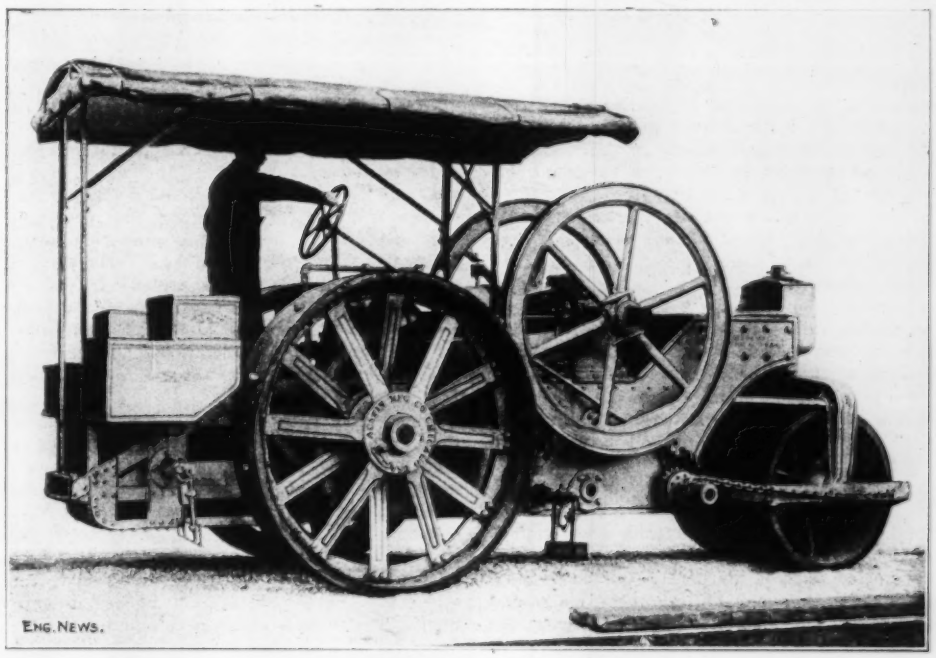
A ROAD-ROLLER DRIVEN BY A GASOLINE ENGINE.

A road-roller operated by a gas or gasoline engine is one of the latest developments in the application of gas-engine power, and a number of special advantages are claimed for this machine, most of which relate directly or indirectly to the elimination of the steam boiler. While quite new in this country, it is stated that rollers driven by gasoline engines are already in use by the government road departments in England and in France.

The machine above referred to, which is now being manufactured by the Austin Mfg. Co., of Chicago, is shown in the accompanying cut. It is made in four sizes, ranging from 7 tons to 15 tons in weight.

In the 12-ton machine, the front roller (in two sections) is 3 ft. 6 ins. diameter and 3 ft. 4 ins. wide on the face. The rear wheels are 6 ft. diameter and 18 ins. wide, and the machine rolls a track or path 5 ft. 10 ins. wide. The wheel-base is 11 ft. The rear wheels have cast-iron tires which are bolted to the spokes of a wrought-iron spider, so that the tires can be easily renewed when worn. Holes in these tires provide for the insertion of studs when used for traction or hauling purposes (as shown), and of spikes when used for breaking up a road surface preliminary to repair and rolling. These holes are plugged when the engine is employed for rolling. An automatic scraper applied to each of the rear wheels keeps the surface clean, but is so fitted as to be forced back by any hard obstruction which might otherwise break it. These are turned down to clear the wheels when they are fitted with studs or spikes, as shown in the cut. The head of the steering fork has an oscillating attachment which allows for uneven movement of the roller in all directions, so as to prevent strain upon the main frame as the roller passes over obstructions.

Two heavy plate frames carry the entire mechanism, and are supported on the rear axle, while at the forward end they are carried by the steering head on the fork of the front axle. A single-cylinder four-cycle horizontal gas engine is mounted between the frames and drives a crank axle having a flywheel at each end; a belt wheel can also be attached. A pinion on



A GAS ENGINE ROAD ROLLER.
The Austin Mfg. Co., Chicago, Builders.

the crank shaft gears with a spur-wheel outside the frames, and from a pinion on the shaft of this wheel there is a train of gearing to the main driving gear on the rear axle. The usual type of compensating gear is employed in transmitting the power to the axle. The gears are of steel, with cut teeth, and the shafts have ample bearings and lubricating attachments, while all parts are readily accessible for inspection or renewal. The arrangement is such that the center of gravity is very low, while at the same time there is a minimum clearance of 15 ins. above the ground. Friction clutches are used, and a single lever controls the starting, stopping and reversing motions, so that the engineman has the machine under immediate control. The steering is effected in the usual way by chains attached to the fork of the front axle and wound upon drums controlled by gear operated from the cab by a hand wheel.

In the 12-ton roller a 25-HP. engine is used, and the maximum speed is about four miles per hour. There is a double speed gear (for two changes) operated from the engineman's platform; in addition to this variable-speed device is attached directly to the governor, giving about 50% range of motor speed. Thus the traveling speed of the machine is controlled by varying the piston speed of the engine as well as by changing the gears. The engine cylinder is cooled by oil circulation, the oil being passed through large air-cooled radiators placed beneath the cab. This avoids all liability of freezing up in cold weather or during cold nights at the beginning and end of the working season. The cylinder exhaust is at the bottom of the machine and is fitted with a muffler of the baffle-plate type, so as to avoid objectionable noise and odor. The tanks have sufficient capacity for fuel for two days of ordinary work, and for work in the country, a tank wagon will hold a fuel supply sufficient for two or three months work.

The roller can be used as a traction engine to haul a roadmaking outfit, or to haul a scarifier for breaking up the surface of old roads. It can also be used as a stationary engine to drive the stone crusher, elevator and screen of a roadmaking plant. It will be seen that in a machine of this kind there is no hauling of coal and water for the engine, no boiler trouble due to bad feed water, and no loss of fuel or time in banking the fire at night or building it afresh each morning. These matters are of importance on work both in cities and in the country, whether for municipal or contract work. The machine can be handled by any intelligent man, and does not need to be entrusted to a licensed engineman.

THE LARGEST GAS PLANT IN THE WORLD, now in course of construction at Astoria, Long Island, is designed to remove from Manhattan Island all plant except the mains and a few holding tanks. When the entire plant is finished it will spread over 400 acres of land and, in addition to the manufacturing buildings, will include a large number of model homes for employees of the company. The six holding tanks (one of which has been finished and running at one-third capacity, is now furnishing Manhattan Island with a quarter of its supply) will each have a holding capacity of 15,000,000 cu. ft. These tanks will have a diameter of 300 ft.; they will reach down into the earth for 50 ft., and will tower above ground 50 ft. Up to this time the largest gas-holding tank has been one of 12,500,000 cu. ft. capacity in London.

REINFORCED-CONCRETE CONSTRUCTION WITH REINFORCEMENT OF STRUCTURAL SHAPES.

Concrete is now used in building construction either as a protective covering to a steel frame or as a primary unit reinforced by steel to take up tension. The former is the necessary result of a steel frame structure which must be protected from the weather and fire; the latter is the development of a new material, to the accurate knowledge of which experience is adding every day. An interesting combination of the above-named methods is now being developed by Guy B. Waite, engineer of the Standard Concrete Steel Co., of New York City, who have already erected several large office buildings with this type of construction.

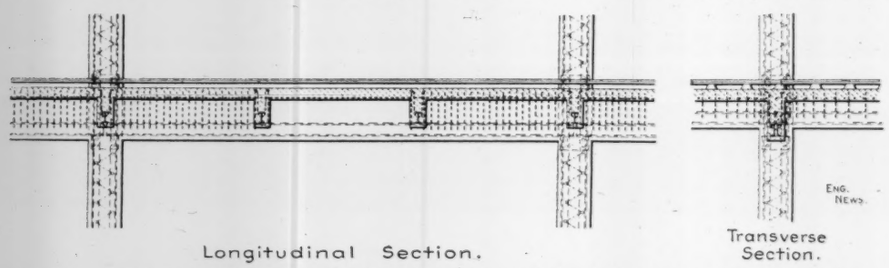


FIG. 1. SECTION THROUGH FLOOR AND COLUMNS IN SYSTEM OF REINFORCED-CONCRETE BUILDING CONSTRUCTION, USING STRUCTURAL SHAPES AS REINFORCEMENT.

In this system a steel frame is first erected of ordinary structural shapes and of a strength sufficient to bear in itself all the erection stresses of the building. Then around the members of this steel frame, concrete is placed in such a fashion as to form reinforced-concrete units, using the steel framework already in place for reinforcement. This steel frame is strong enough not only to stand wind and dead loads due to its own erection, but also to support the forms and green concrete until the reinforced concrete begins to act as such.

Fig. 1 shows a typical cross-section through floor and column from which the method of construction is readily understood. The original girders and beams consist of small I-beams, usually from 4 to 5 ins. deep, entering into the columns and connected to them by bent plates and angles. The column itself consists of four angles latticed together, so designed as to form, when filled with concrete, a hooped reinforcement. The column detail is capable of variation.

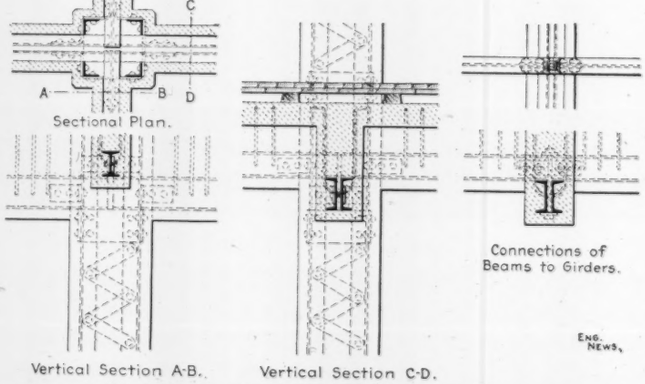


FIG. 2. DETAIL OF COLUMN AND GIRDER CONNECTION REINFORCEMENT OF STRUCTURAL STEEL SHAPES.

A cast-iron or structural steel column may be substituted designed to take the entire stress coming down the column and covered with concrete merely as a protection.

The forms for concrete are hung to the I-beams and with these beams and U-shaped bars, running through holes in the webs for reinforcement, the concrete beams and girders are formed. The company claims that the structure can be so designed, in accordance with the accepted rules for reinforced concrete, as to give a correctly proportioned concrete beam and still have enough steel in the tension members to properly take all the erection stresses. The floors are laid upon the beams and girders in the ordinary method and reinforced with any of the rods or bars now being generally used.

Especial attention is paid to the connection between beam and girder and girder and column. Fig. 2 shows standard connections. It will be noted that each I-beam is riveted by a plate connection to the column angles and that all girders and beams in line are bolted together to ensure continuity of beam action.

The shear reinforcement is held firmly in place in the web of the I-beam and is therefore not so liable to be bent and twisted from its designed place. The shear bars are spaced in the beams closer at the supports where maximum shear obtains and are left out altogether between middle beams on the girder on account of the absence of shear between these two points.

Figs. 3-5 illustrate the system as built in two commercial buildings in New York City. Fig. 3 is a view of the steel framework before any concrete work has been started. Fig. 4 shows the beams in place with their shear reinforcement preparatory to putting in concrete and Fig. 5 the work of concreting going on. In the ceiling of the floor shown in Fig. 5 the method of suspending the forms can be very well noted. The forms are all made in the shop, brought to the work in full size for each beam and hung from the beam by wire looped at the bottom to permit entrance of the cross-bars shown which support the forms.

THE POLLUTION AND SELF-PURIFICATION OF NATURAL ICE.*

In view of the recent general interest in the question of ice as a vehicle of transmission of disease, it is felt that a short statement setting forth our knowledge of the pollution and self-purification of ice, and demonstrating what dangers, if any, lurk in our public ice supplies and exert an influence in the transmission of typhoid fever and other water-borne diseases, would be timely and appropriate.

To the average layman there are unfortunately many apparent vagaries in the field of sanitary science. His knowledge is usually gained only through the medium of the public press, and then frequently at the hands of the amateur sanitarian, who, with zeal greater than his wisdom, promulgates opinions which are as likely to be erroneous as correct.

Knowledge of the results of scientific investigations filters very slowly through the student and laboratory down to the average citizen. So it happens that the results of investigations of ice conditions made twenty years ago, but which are now almost entirely superseded by later tests, exist to-day in the minds of the people as little more than mere "solidified delusions."

The examination of ice or water, or sewage, or foods, or of any other substance directly of interest to the public health, must be made by trained sanitary experts, and not by men who, although well drilled, are simply chemists and simply bacteriologists.

Experimentation and investigation along sanitary lines must take in consideration every varying condition, must continue over sufficiently extended periods of time, must be under strict control, must not be subject to outside influences urging the arrival at certain conclusions, and must formulate conclusions only after skilled interpretation of results.

The question of ice infection has been made the subject of special investigation and experiments for more than a quarter of a century. It was scientifically studied by eminent authorities abroad as early as 1871. Some twenty years ago it was studied in this country by Prudden, and later by Sedgwick, Clark, Mason and other eminent sanitarians and biologists.

*Slightly condensed from the leading article in the Bulletin of the New York State Department of Health for March, 1907 (Albany, N. Y.).

There are but a very few cases on record, either in this country or abroad, where intestinal diseases have been traced to ice as the vehicle of infection. Of these we must clearly distinguish between intestinal disturbances caused by decomposing organic matter and diseases such as typhoid fever or cholera caused by the specific germs.

The first epidemic of disease directly ascribed to ice was reported by Dr. Nichols, of Boston, at the summer resort of Rye Brook in 1875. The illness was of a severe intestinal disorder, but was not typhoid fever. The milk and water supplies were found to be above suspicion. The ice supply was discovered to have been cut from ponds whose waters were rendered foul and putrescent from a mass of decomposing sawdust and marsh mud. The epidemic was confined almost exclusively to one hotel, but the fact that other cases occurred outside of the hotel, which used the same ice supply, seemed to strengthen the evidence as to the cause of the epidemic.

In 1878 Dr. Smart, of the Medical Department of the U. S. Army, attributed a small outbreak of malarial fever at one of our western garrisons to contamination of western streams by melting snow during the spring of the year. The water was found to contain much organic matter and according to Dr. Smart contained also the "materies morbi" of malaria, the alleged cause of the fever. [We now know that malaria is not spread in any such manner.—Ed.]

In 1879 the State Board of Health of Connecticut reported a small epidemic of dysentery at a farm house where, out of eleven persons, eight were stricken, three fatally. The drinking water gave satisfactory analysis, but the soil surrounding the house was damp and polluted. The ice was taken from a small stream which was frequented by swine. Analysis of the ice water showed it to be highly polluted, though not necessarily infected. The investigators attributed the cause of the disease to this ice supply.

Three years later there was reported by the same Board a single case of typhoid fever probably due to ice infection. The patient had lived alone for several months in a house where the sanitary conditions were in no way open to suspicion. He had used freely ice that was cut from a pond into which drainage of three typhoid patients was discharged. The presumption was that infection was transmitted through the ice taken from this pond.

In 1902 Drs. R. H. Hutchings and A. W. Wheeler reported an epidemic of typhoid fever at the St. Lawrence State Hospital at Ogdensburg, N. Y. In all 39 cases of the disease occurred under conditions which led the investigators to conclude that the use of ice taken from Oswegatchie River at a point where it had been contaminated by dejecta from several typhoid fever patients was the primary cause of infection. It was alleged that lumps of dirt frozen in the ice showed, upon examination, cultures that were true typhoid bacilli.

It should be stated, however, that there were circumstances associated with this epidemic that merit especial consideration as to ice contamination. The evidence that large and visible lumps of dirt were found indicated that the ice was either frozen when the water was in rapid motion, an unusual condition, or that infection may have occurred from extraneous sources, such as from infected shoes of laborers during ice cutting, flooding of ice, etc. That this may have been the more probable cause was strengthened by the fact that only one out of several ice houses filled with ice from the same source was in any way brought under suspicion.

Finally, there was reported by Dr. Dorange, in France, a supposed ice epidemic at the military post of Rennes in the autumn of 1895. Eight lieutenants were taken ill between the 12th and 25th of December following a regimental banquet on Dec. 4. These officers did not live in common and a military banquet was the only common occasion during which infection could have occurred. The water supply could not be questioned, but all of these officers had partaken of champagne mixed with iced water. The ice was taken from the town supply, which was known to be polluted. A further fact cited was that officers of different rank were served from different menus and that the petty officers who did not drink the champagne escaped the disease.

The attributed cause of the epidemic, as in the case of the St. Lawrence Hospital, leaves much to be explained. No mention is made, for instance, of the effect of this ice supply upon the residents of the town, who used it with apparent impunity; nor is there mention of oysters in connection with the menu and the reasons for excluding this as a possible source of infection.

In reviewing these epidemics, which constitute the practical evidence of an epidemiological nature upon which we are to judge of the dangers of ice infection, it appears that it is a case of treading upon very thin ice. Out of some six epidemics of disease attributed to infected ice, in only one was the number of cases reported greater than a dozen. Four of them might be termed merely intestinal disorders, due to decomposing organic matter and not to specific germs. Of the two epidemics of typhoid fever, the circumstances connected with them were, as stated above, of such a nature as, judged from our present knowledge and later experimentation and observations, to cast considerable doubt upon the alleged cause of the infection.

After thus historically reviewing this class of evidence as to the real or supposed danger of ice in the transmission of typhoid fever and its allied water-borne diseases, we are now readily able to understand the factors and agencies that render harmless any infection that may have been originally present in any ice supply. We are also better able to understand why, notwithstanding the frequent polluted sources of ice supplies, the good people of this and other States have not succumbed to serious ice epidemics of typhoid fever.

So plausible has been the theory that polluted or contaminated water must produce an infected and dangerous supply of ice that a large amount of original and independent lines of investigation of the bacteriology of ice supplies have been carried on by eminent sanitarians, including engineers, biologists and chemists of considerable note.

It will hardly be possible in the space here available to attempt to give in any detail the results of these important investigations and experiments. In fact bibliography alone includes reports and treatises of some 130 eminent investigators of unquestioned repute, dating back as early as 1871, and the knowledge we have gained from them has been made the basis for practice in this particular field of sanitation.

In general there are a great many conceivable ways that ice and ice supplies may become infected. The danger from many of these causes of infection may, however, be so remote or so infrequent as to hardly merit notice. There are, however, a few dangers associated with the formation of natural ice and the harvesting of ice supplies, as now generally practiced, which do merit consideration.

The first of these dangers is the one due to the harvesting of ice from polluted sources. This ice may be taken from ponds or rivers which have been polluted by sewage and may contain the germs of typhoid fever and other diseases.

Secondly, ice may become contaminated during the period and operations of harvesting by filth which may have come from infected sources. The hands and feet of laborers or the hoofs of horses may be the channels by which infection may be transmitted to the ice, even after it has been taken from the water, and notwithstanding the purity of the water.

Thirdly, ice may become infected from surface drainage from the adjacent lands, during thaws. The water which has thus flowed over infected fields that may have

FIG. 3. VIEW OF SKELETON STEEL FRAMEWORK BEFORE CONCRETE IS PLACED.

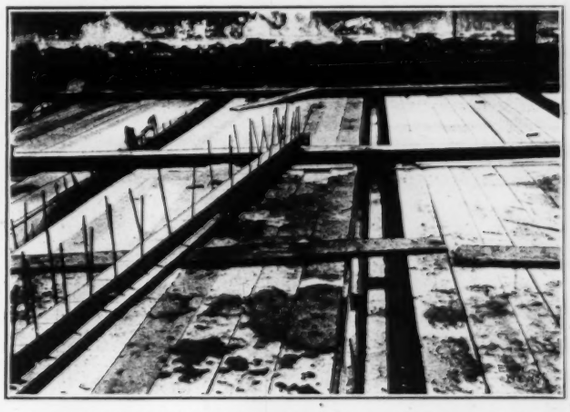


FIG. 4. VIEW SHOWING I-BEAM REINFORCEMENT WITH U-SHAPED SHEAR BARS.

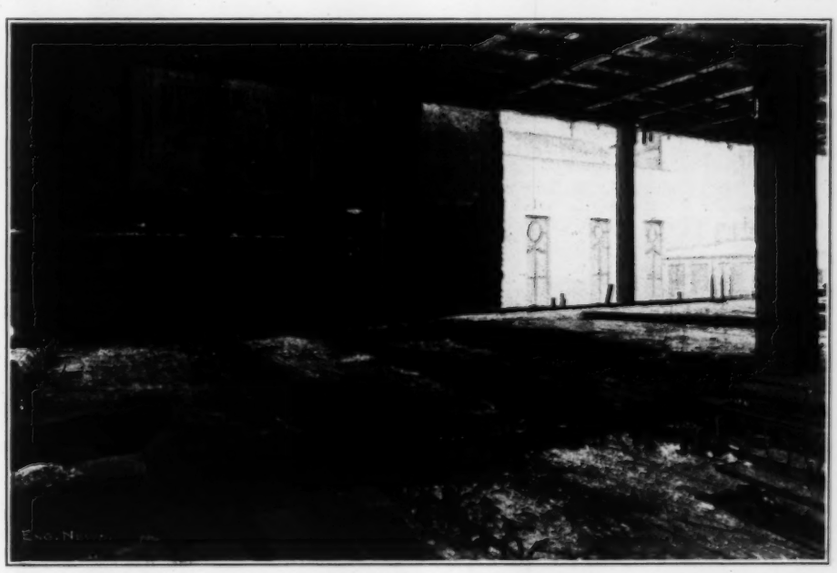


FIG. 5. VIEW SHOWING CONCRETE IN BEAMS AND GIRDERS. METHOD OF SUPPORTING FORMS SHOWN AT CEILING.

been fertilized or otherwise infected, may be carried on to the ice and settle and be frozen into it.

Finally, ice may become infected from the exposure and handling incident to distribution of it in our cities and even within our homes. This may be by far the most serious mode of infection, for it leaves the time interval between infection and transmission too short for any counteracting influence of cold to be exerted.

The reason for so small a mortality from ice infection, or, indeed, of any of which we have authentic record, is due to a series of natural agencies or safeguards that nature has bountifully bestowed upon us and which tend, by a process of successive elimination, to reduce or entirely destroy the bacterial or germ life that may have been originally present in the polluted water or have infected the ice after its formation, or even after harvesting.

The first safeguard or influence which is active in the reduction of bacterial life is the well established phenomenon of subsidence and oxidation upon suspended matters, including bacteria in bodies of quiescent or slowly flowing water. This action, of course, will effect in the greatest degree the purification of ice harvested from ponds and lakes. It effects in a large measure, however, ice collected from rivers, and especially those in which the velocities are slow enough to admit of formation of ice of sufficient thickness to warrant harvesting. For rivers of this class we may say in general that a removal of bacteria to the extent of from 50% to 75% will be effected in a run of from 10 to 50 miles. In quiescent bodies of water this removal is correspondingly greater.

The second agent in the self-purification of ice is the removal of suspended and dissolved matters which is brought about during the action of freezing. It is commonly known as the "filtration process of freezing," and it effects not only the suspended matters, such as particles of dirt and bacteria, but also chemicals that are in solution. This purification will vary somewhat with the degree of quiescence of the body of water during freezing, but will result in general in a reduction of about 90% of the suspended particles and bacteria. Of the chemical compounds the elimination will average about 25%, ranging from say 10% to 40 %, according to the constituent.

Of perhaps the greatest influence in the self-purification of ice is the effect of low temperature upon the vitality and life of the bacteria themselves. It has been found by nearly all observers that bacteria exposed to low temperatures near the freezing point very soon lose their vitality, and if exposed for a sufficient length of time are either killed or become so attenuated as to be non-pathogenic, i. e., their vitality has been so lowered that they are unable to be sufficiently revived to produce disease. This effect of low temperature upon the vitality of bacteria is proportional in a measure to the degree of cold, but of much more importance is the effect of the time of exposure. According to our best authorities, we may say in general that bacteria are reduced in number about 50% after exposure to freezing temperatures for a period of one hour; 90% after 24 hours; and practically 100% after exposure from two to three weeks. The few that are not killed after exposure for say one month have become so attenuated as to be unable to produce disease.

There is still another influence depending upon time of exposure that must not be confounded with the phenomenon of cold alone. This is the influence or destruction of pathogenic bacteria when exposed or disseminated through a body of water. It has been found that without special relation to temperature, pathogenic bacteria are slowly killed when discharged into a body of water. This is probably due partially to the fact that water is not a favorable environment to most species of pathogenic bacteria accustomed to environment in a human being, and partially to the fact that when exposed to the ravages of other water bacteria they are soon destroyed. As to the fate of bacteria discharged into bodies of water, especially moving bodies of water like rivers, we may say in a general and perhaps conservative way that over 99% are destroyed in from 30 to 60 days.

As a striking illustration of the influence of these self-purifying agencies and the effect which they have in eliminating infection from our natural ice supplies, we may take the case of an ice crop harvested from a rather polluted section of one of our rivers, which has, we will say, been stored in an ice house for a period of some months before its delivery to consumers. Let us assume that the original number of bacteria per cc in the river is 1,000,000, a number corresponding to ⅓ or ½ raw sewage. Let us further assume conservative figures of reductions or "efficiencies of purification," corresponding to the four influences above described, of 50%, 90%, 99% and 99% respectively.

Under these conditions and assumptions, then, we find that of the 1,000,000 originally assumed only 5 remain in the ice at the time of delivery to consumers. This is equivalent to a reduction of 99.95% of the bacteria originally present. Compared with the efficiency of our best municipal filters of the slow sand type, which in practice cannot be expected to give a removal of more than 99%, we find that the combined efficiencies of the natural purification of ice exceeds that of the sand filter by some 200 times.

It is thus evident why, as previously questioned, ice pollution has been robbed of its apparent dangers and why the records show so few, if any, cases of epidemics of typhoid fever due to this mode of transmission. These facts, while emphasizing the great immunity bestowed by nature, point, however, to the real dangers of ice infection with renewed force. There still remain, for instance, the infection due to handling and distribution; to surface pollution due to the pernicious practice of flooding ice to get a thicker crop; to surface pollution due to rains and melting snow washing pollution from side slopes on to ice that has already formed; and finally to the dangers of artificial ice when this has been manufactured from contaminated water and delivered to consumers before the natural processes of purification have had an opportunity to become active or effective.

It is for the removal of some of these possible or residual dangers, notwithstanding the high efficiency of natural purification, that regulations looking to the conservation of our ice supplies become desirable if not necessary. There are unscrupulous people in all trades, and it needs no proof to show that ice harvested from the vicinity of sewer outlets would be loathsome if not dangerous. In fact, even if there were no danger from such a procedure, there would still be an aesthetic objection to organic and other filth associated with polluted waters that make incumbent the forming of laws for the protection of our ice supplies.

The [New York] State Department of Health is at present vested with no authority controlling the cutting of ice, and has no funds on hand with which to carry on such a work. The Department has had under consideration for some time the question of the control and regulation of the ice business, and has prepared a measure which will be shortly introduced in the Legislature which it is believed will afford an effective supervision over the subject and will safeguard the public health from this source of danger.

A TAPE LEVELING ROD AND ITS USE.

By ARTHUR W. TIDD,* Assoc. M. Am. Soc. C. E.

The sliding tape rod described in this article, by means of which elevations are read off directly, has been thoroughly tried out, both on preliminary work and construction, by over ten years' experience, and has proven itself to be practical and economical. The Metropolitan Water Board of Boston, Mass., has given it a most thorough trial, using it almost exclusively on the construction of the Wachusett Reservoir, the Wachusett Aqueduct and the Weston Aqueduct.

The principle is simple and the application not at all new. Take any self-reading level rod, number the foot and tenth marks from the top downwards and set up so that the H. I. is the same value as the elevation of the bench mark; then all other readings taken from that set up are actual elevations. For example, if the bench is 367.25, the level is set up so that the cross-hair intersects 7.25 on the rod when held on the bench, and if the ground rises a foot at the next shot, since the graduations increase downwards, the cross-hair will intersect 8.25, and the elevation

*Assistant Engineer, Board of Water Supply, New York City.

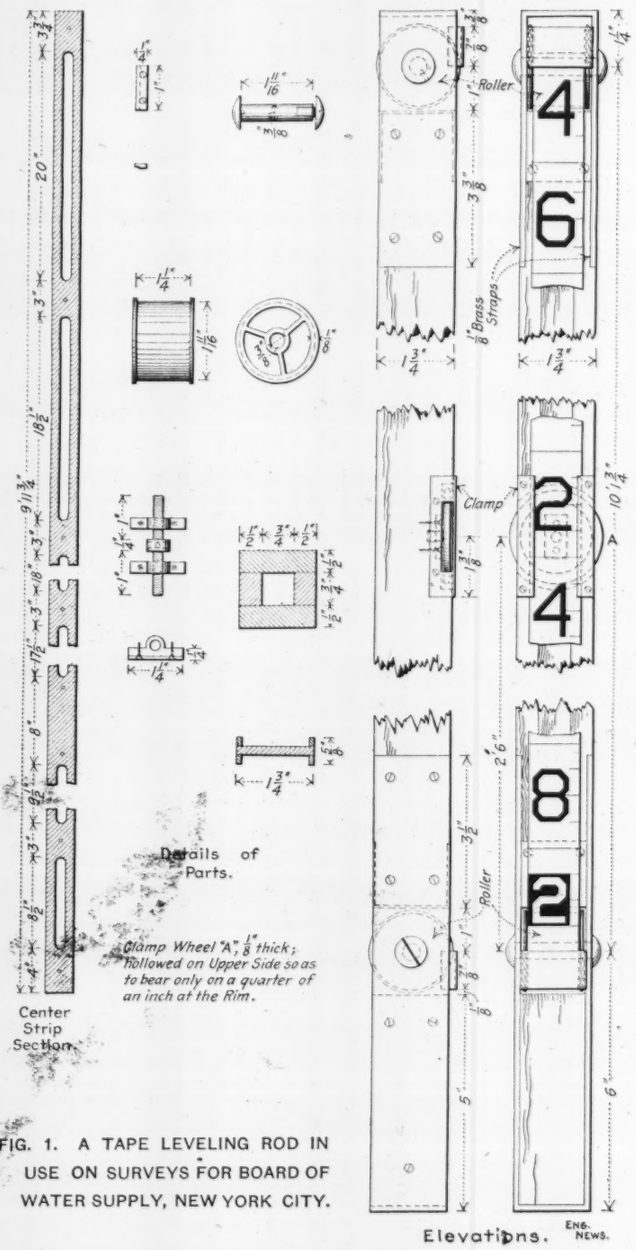

Roller
Brass Straps
Clamp
Roller
Details of Parts.
Clamp Wheel "A", ⅛" thick; Hollowed on Upper Side so as to bear only on a quarter of an inch at the Rim.
Center Strip Section.
Elevations.
ENG. NEWS.

FIG. 1. A TAPE LEVELING ROD IN USE ON SURVEYS FOR BOARD OF WATER SUPPLY, NEW YORK CITY.

Fig. 2.
A Tape Leveling Rod.

will be 368.25. Now, it is a rather tedious process to set up to the nearest hundredth, although by no means impossible; so, instead of moving the instrument up and down on the graduations, this particular rod moves the graduations up and down on the instrument. The graduations are painted on an endless tape moving over the face of the rod, by means of which any elevation can be brought to the cross-hair of the level. Of course, the numbers run downwards, and the rod has to be read downwards.

The views and plan of details (Fig. 1) illustrate the general design. The rod is partly hollow and weighs 10 lbs.; as it is only 1¾ ins. square, it is readily handled with one hand if necessary. The tape is a steel ribbon, painted white, with graduations in black. The gage may range from No. 30 B. W. G. to No. 34. It is usually graduated to show the tenth and half-tenth marks, the intermediate hundredths being estimated when required.

The rod is used for taking cross-sections, running profiles, setting slope stakes and giving grades on construction. It is admirably adapted to the rapid running of preliminary railroad, aqueduct or highway lines, where it is desirable to know the actual elevation at all times. It finds a ready use for all kinds of work in the brush; it is easily distinguished and read through the leaves, and will stand rough handling. By its use the columns of foresights, backsights, rod readings, etc., are not required, and the laborious note-book reductions are entirely done away with, saving space and time as well as eliminating the chances of arithmetical errors.

A case in point illustrating this economy may be cited in the stripping of the Wachusett Reservoir.

The stripping was measured by squares 25 ft. on a side, an elevation being taken at the center of each square before operations commenced and again after the stripping was finished. The entire area of over 7 sq. miles was laid out in large squares, 500 ft. on a side, and each given a number by which that square was designated throughout the work. Ordinary field note-books were provided for recording the original and final elevations, each double page ruled up to represent a 500-ft. square divided up into the 25-ft. squares. Each elevation was entered in its proper place as fast as taken, and any shot duplicated, left out or incorrectly called would be spotted by the recorder and rectified then and there on the ground. Two pages, then, served to record 400 shots.

Under the other system of carrying columns of backsights, rod readings, elevations, etc., two pages would average about 65 shots, and it would take eight to cover a 500-ft. square. Errors and omissions in the field work would not be detected until the record sheets were plotted up in the office, too late, oftentimes, to correct them. The reduction of the notes increases the office work considerably, and the field work is delayed because the name of each shot has to be recorded as well as its rod reading. As the total number of shots reached 650,000, the saving was quite material. The regular parties consisted of an instrument man, recorder and two rodmen using tape rods, and it was not uncommon under favorable conditions to keep three tape rods busy.

The Clinton Machine Works, Clinton, Mass., manufacture the rods to order; complete without the tape. Ledder & Probst, 9 Province Court, Boston, Mass., furnish the steel ribbon for the tapes, which have to be painted, graduated and fitted to the rod by the rodmen at odd moments and rainy days. Brass stencils are used for marking the numbers, each foot mark being on a separate stencil and the 2, 4, 6, 8 tenths all on one.

As regards painting and graduating the tape, the following suggestions may be of value. Three coats of best white lead and oil paint will suffice for the ground work, each coat thoroughly dried and smoothed down with fine sand-paper. This seems to be the only material that is of sufficient elasticity and adherence to stand running over the rollers. Then, too, it is to be remembered that after a summer of hard usage the tape may have to be scraped and repainted and the rod itself given a coat of shellac and varnish. Such repairs, by requiring only ordinary materials and ordinary skill, become quite an inexpensive item. The tenth and half-tenth marks are ruled on with black oil or varnish paint with an ordinary right-line pen, using a steel tape graduated to hundredths stretched alongside for a guide. The numbers are outlined by going around the stencils with a soft pencil. For filling them in a No. 2 artist brush will give good results. Begin with the six-tenths mark above the O and end with the four-tenths mark below the 20. One coat of any high-grade colorless varnish, using the consistency as it comes in the can, completes the tape.

The right and left thread device for clamping the two ends of the tape together and bringing it to the proper tension must be put on carefully and accurately to line, and the end of the tape turned over so as to bring a double thickness through the clamp. It is well to lubricate the roller bearings with graphite. When not in use the rod should be laid flat on the floor or supported on three or four brackets.

LINING TRACK BY THE USE OF JACKS.

The work of lining railway track is usually effected by a gang of six to ten men with lining bars (half the men at each rail), the bars being stuck into the ballast and the men heaving on them simultaneously at the word of the foreman. The work is severe, and on branch lines with small forces, or on main lines at seasons when the section gangs are reduced, it is necessarily

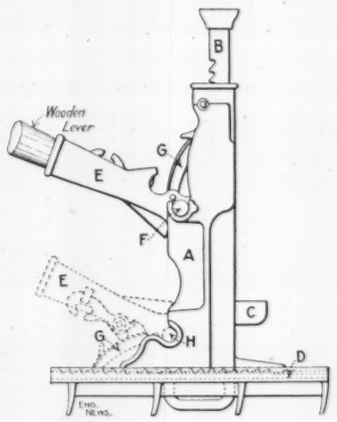


Fig. 1. Track Lining Jack.

Buda Foundry & Mfg. Co., Chicago, Makers.

neglected to a considerable extent until such time as the force is increased, or is temporarily recruited by men from other sections. In some cases a special or floating gang is sent to do this work in order to put the track in proper condition. To obviate this difficulty by enabling two men to adjust track to line, and at the same time to do the work better and quicker than the ordinary lining gang, a special form of track jack has been devised which has a lateral travel on a bed plate, in addition to the ordinary vertical lift.

The construction of the jack is shown in Fig.

Fig. 2. Lining Track with Jacks.

1. At A is the frame or pedestal of the jack, with lifting bar at B, on which is the claw or foot C to fit under the rail or tie. The horizontal bed plate D is of channel section, with a rack in the bottom and having ribs under the bottom which give it a grip in the ballast. The jack proper can be lifted off the base plate, and each part has a handle for convenience in carrying from place to place. The jacks are used in pairs, as shown in Fig. 2. The ballast is removed from between two ties to allow the base plates to be pushed under the rails and firmly bedded; each jack is then slipped into the grooves of its base plate and slid along until the foot C is under the rail and the frame bears against the edge of the rail. By means of the lever E working in the upper fulcrum at F, and having a pawl G engaging with the rack on the bar B, this bar is raised until the ties are just clear of the ballast bed (but not enough to allow dirt to fall in beneath them). If the ballast is heavy, it may be loosened around the ends of the ties in the direction the track is to be thrown. The lifting bar is then held in place by a dog or latch while the lever E is removed and set at the lower fulcrum H, the lever being inverted so that the pawl G engages with the rack in the base plate. Then by working the lever the jack is forced along the base plate. With the two jacks worked simultaneously the track is readily thrown to line. When the required movement has been made, the lever is again set in the upper socket, and the bar raised slightly to allow the latch to be tripped, thus dropping the ties upon their beds.

Where it is not considered advisable to put one jack inside the rail, both may be set outside. In this case, both are used to raise the ties, but the one on the side to which the track is thrown becomes simply a carrier, the other doing all the work of forcing the track over. These jacks are available not only on open track but also in lining grade crossings which have been thrown out of line by the creeping of the rails, etc.; this is heavy work and would ordinarily require a large gang of men. They may also be used in wrecking work and in rerailing cars. When removed from the base plates they can be used as ordinary track jacks. The jack has a lifting capacity of 12 tons, and weighs 105 lbs.; its height with the bar lowered is 24½ ins., and the bar has a vertical lift of 12½ ins. The frame and base plate are of malleable iron; the racks are of forged steel, with machine cut teeth, and the pawls, pins and bearings are of steel. The jacks are in use on a number of roads, and are manufactured by the Buda Foundry & Mfg. Co., Railway Exchange Building, Chicago.

A 112-TON TANK ENGINE of the 2-8-2 class has been built for the Nevada Northern Ry., for use in the traffic between the mines and smelting plant of the Nevada Consolidated Copper Co. The tanks extend on each side of the boiler from the cab to the smokebox, and have the inside plates curved to the outline of the boiler in order to increase the width and capacity. On the right hand side, therefore, an L-shaped pipe is built into the tank to carry the reach-rod from the reversing lever and the upper end of the arm on the reversing shaft. The coal bunker is behind the cab. All the driving wheels are flanged, and the third pair are the main drivers. The spring rigging is connected to form two groups, each including two driving axles and one truck. The boiler is set high above the frames, but the tanks keep the center of gravity moderately low. The engine was built by the American Locomotive Co., and its principal dimensions are as follows:

Driving wheels	4 ft. 0 ins.
Truck wheels	1 " 5 "
Journals, driving axles	8½ × 12 ins.
Wheelbase, driving	15 ft. 0 ins.
Wheelbase, total	34 " 0 "
Weight on driving wheels	172,000 lbs.
Weight, total	225,000 "
Cylinders	19 × 26 ins.
Boiler, diameter	5 ft. 6⅝ ins.
Boiler, rail to center line	9 " 5 "
Working pressure	200 lbs.
Firebox	8 ft. 11½ ins. × 5 ft. 2½ ins.
Tubes, 304; diameter	2 ins.
Tubes, length	15 ft. 8 ins.
Heating surface, tubes	2,478 sq. ft.
Firebox	166 " "
Total	2,644 " "
Height, rail to top of smokestack	15 ft. 2 ins.
Capacity of tanks	2,500 gallons.
Capacity of bunker	5 tons.
Tractive effort	33,240 lbs.

A REMARKABLE TEST OF REINFORCED CONCRETE CONSTRUCTION.

Reinforced-concrete buildings which remained uninjured even when tilted at an angle of about 25°, and were eventually returned to their normal positions, form an interesting offset to the failures of reinforced concrete buildings which have been recorded. The buildings which sustained this severe and remarkable trial are at the town of Tunis in north Africa; they are owned by the Societe Minoteries Tunisiennes, and were built last year by Odorico & Co., at a cost of about $300,000. They stand on the marshy ground occupied by the French town, and lying between the shore of the Mediterranean and the hills on which the Arab town is built. The material is a very soft mud, and it is stated that many of the buildings of the town are tilted in various directions, while the surface of the ground rises in ridges due to the displacement of the soft material.

The buildings in question are two five-story grain and flour warehouses, about 45 × 100 ft. and 50 × 125 ft., respectively. These are parallel to each other, and between them is a flour mill, 112x112 ft., the three forming a channel shape in plan, but not being connected in any way. The middle building (mill) was not affected, but the two side buildings tilted outward as described below. A well 41 ft. deep was sunk without finding hard ground, and the foundation excavations were then made to a depth of 10 ft. No piles were used, but the column footings were connected by inverted arches 6 ft. wide to form a spread foundation. The foundation columns were 32 ins. square, and upon these, at a height of 30 ins. above the ground was built a framework of steel I-beams (from Italy). These were arranged in longitudinal and transverse rows, with diagonals, as shown in the sketch plan, Fig. 1. Wooden forms were placed around these and filled with concrete well rammed. As to the details of the superstructure and the type of reinforcement we have not been able to obtain information, but it is evident that good materials were used and were properly handled. All the concrete for the buildings was mixed by hand and composed of 1 part of Boyer Portland cement ("Ciment Romain Boyer," from Marseilles, France), to 3 parts of sand and gravel. Tests of briquettes composed of 1 part cement to 3 parts sand (age not stated) showed an average tensile strength of 380 lbs. per sq. in.; these tests were made under the direction of the engineers—Didier, Barsotti and Archer. About 2,500 tons of the Boyer cement were used in these buildings.

In June, 1906, just after completion, one of the side buildings was observed to be settling along the outer long side, inclining outwards from the central building until it eventually came to rest at an angle of about 25°. As it did not collapse, and showed (as we are informed) no cracking or deformation, the engineers undertook to return it to its proper position. On the higher side was piled 4,000 tons of sand in sacks, 2,000 tons in the basement and first floor, and the balance in the upper floors; excavations were also made under this side, to allow the material to be easily displaced under this loading. In a few days the building was restored to the vertical position. In August, the building on the other side began to settle in the same way, along the longer side on the outer face. It was being loaded for test purposes, and a transit had been sighted upon it; the movement began when about 1,500 tons had been deposited on the floors, and the progress of the movement was as follows, the figures representing the overhang of the top above the base at the ground line: 1 in. at 7 a. m.; 3 ft. at 2 p. m.; 9 ft. at 6 p. m.; 9 ft. 11 ins. at 7 p. m.; 14 ft. at 9 p. m., and a total of 17 ft. at midnight. The building turned around an axis at about the middle of its cross-sectional area, the level of the first floor on the high side being about 9 ft. above its normal level. The test loading was transferred to the high side, and supplemented by additional material, while excavations were made under the high side, as in the case of the other building.

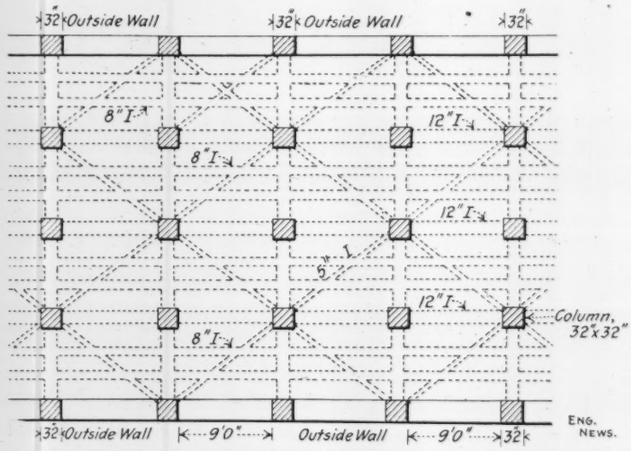


FIG. 1. SKETCH PLAN OF STEEL FRAMING IN THE FIRST FLOOR OF THE REINFORCED-CONCRETE WAREHOUSE AT TUNIS (NORTH AFRICA).

The results were entirely successful as far as the straightening of the buildings was concerned, but the buildings are now 15 ft. to 18 ft. below their original levels. We are informed that in each case the entire mass was displaced as a monolith, all parts remaining intact in their relative positions; no cracks appeared and all the window openings remained in line. This is considered as ample proof of the strength of the reinforced-concrete construction, the fault being in the foundations. Fig. 2 is an end view showing the three buildings and the "leaning tower" appearance of one of the tilted warehouses. Fig. 3 is a general view showing the general design and character of the tilted building. For photographs, and for particulars from which this description is prepared, we are indebted to Mr. H. P. Fountain, 205 Ontario St., Chicago.

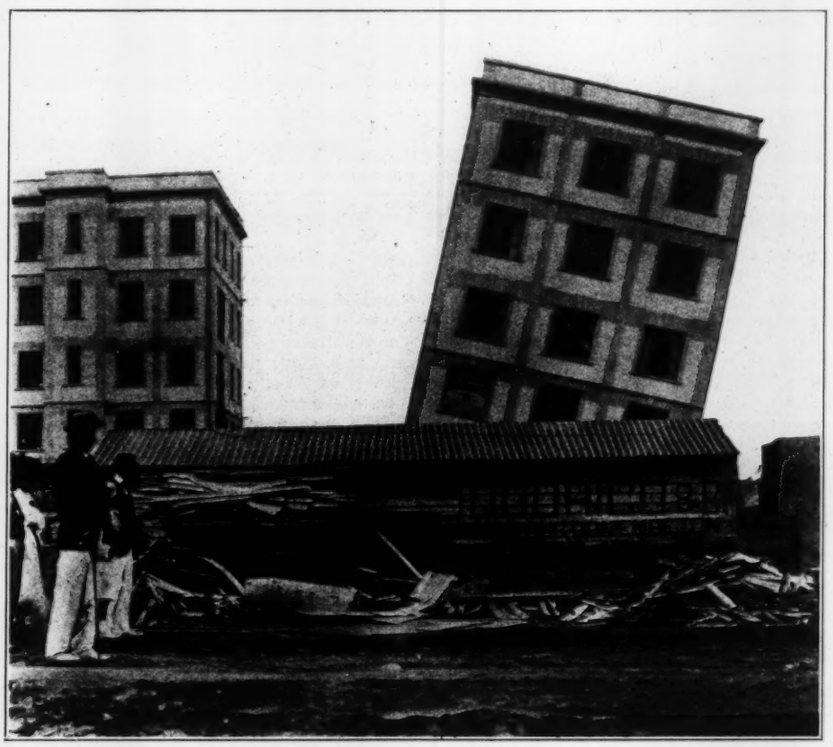


FIG. 2. REINFORCED-CONCRETE WAREHOUSE TILTED BY THE SETTLEMENT OF THE GROUND UNDER THE FOUNDATION.

(Copyright, 1906, by Henry Wilson, Chicago.)

NEW STREET RAILWAY REGULATIONS IN PRUSSIA

Under the direction of the Minister of Public Works, and by request of the street railway companies, the government rules and regulations affecting street and local railways in Prussia have been revised and made more explicit, so as to ensure less friction and trouble between the companies and the government authorities. Some extracts from these are given below, and are of interest as indicating the way in which public safety is guarded under government regulation. Particular attention may be called to the paragraphs relating to brakes, inspection and accidents. The police regulations are selected from a number which are recommended for adoption by municipal authorities, in order to ensure greater uniformity than that which exists at present:

GRADES.—In general, grades shall not exceed 1 in 15 (6.66%), but steeper grades for short distances shall be permissible if operating safety is demonstrated by experiment.

TRACK.—Lines on public streets must be laid with girder rails or compound rails with guards or flanges high enough to give a running tread for street vehicles. In general, curves shall not be less than 49.2 ft. radius, and where the conditions permit, the outer rail should be elevated. On straight track the rail grooves shall be at least 1 3-16 ins. wide, but not wider than 1 9-16 ins., except that they can be wider on curves according to the gage. If they become wider through wear, the rails can be kept in service until worn out. All rails, switches and other parts of the track on public streets must be so laid that they will not interfere with traffic.

In conduit systems the conduit may be placed in the middle of the track or under one rail. The slot on straight track must not exceed 1 3-16 ins., and on curves 1¾ ins. in width.

The distance from the center of the track to the curbstone must be at least half of the greatest width of the car. On turnouts and on double-track sections the distance between centers of rails must be at least 16 ins. more than the greatest width of the cars. On curves this same distance must be observed where local conditions permit.

BRIDGES.—Iron bridges maintained by the railway

company must be examined at least every five years, and records of these tests must be kept.

WIRES.—Span wires attached to the sides of houses must be provided with means for deadening sound and preventing rattling.

POWER.—The railway company must at all times have sufficient auxiliary power to take care of extra heavy traffic and unfavorable traffic conditions without disturbing the operation seriously. In the case of damage to machinery, the reserve must be sufficient to maintain the schedule of a working day. If the railway has no power station, but purchases its power, these regulations apply to the station selling the power.

FIG. 3. GENERAL VIEW OF TILTED WAREHOUSE.
(Copyright, 1906, by Henry Wilson, Chicago.)

WHEELS.—All wheels excepting those on the middle axles of three-axle locomotives and cars must have flanges. At speeds up to 15½ miles per hour, these flanges, assuming they are used only on girder rails, may be worn down to ½-in. in height and 5-16-in. in thickness. At higher speeds and with T-rails the size of flanges must conform to that fixed by the engineering commission for railways. The thickness of the wheel tires, where the weight per wheel is 3 tons, must be at least ⅝-in., and for greater wheel weights at least 11-16-in. On all other rolling stock the tires may be worn down to 9-16-in.

COUPLERS.—All rolling stock, except construction cars, must have spring couplers at both ends.

SCRAPERS.—Track scrapers must be used on all cars. Their height above the rails shall not exceed 2.5 ins. where all of the pavement is asphalt; 3.1 ins. where pavement is either asphalt or stone; and in no cases, even on outside lines, must it exceed 3.9 ins.

BRAKES.—All motor cars must have at least two independently operating brakes; one of these must be mechanical, such as air brake, electrical short-circuiting brake, or electro-magnetic brake. All cars, except freight cars, must have hand brakes. When more than one trail car is used the braking arrangement must be such that the motorman can apply all brakes throughout the train at once. Exceptions are permitted by the commission in certain cases where the operating conditions are very simple. Simultaneous train braking may also be required with one trail car if the traffic conditions are severe.

All brakes should operate as noiselessly as possible, be actuated from either end of the car, and of such capacity that a car with full load on a dry rail at a speed of 6.25 miles per hour may be stopped in a distance of 19.5 ft. from the point of the application of the brake-shoes. The commission reserves the right to make severer regulations when it appears necessary.

Motor cars and locomotives must be fitted with effective sanders.

CARS.—The seating space to be allowed per passenger must be at least 19¼ ins. wide, except that cross seats may be somewhat narrower when allowed by the commission. All cars must be lighted, and, if fitted for electric illumination, there must also be auxiliary lighting. The commission can also specify when the cars must be heated. Every car must be fitted with some means of signaling between the conductor and the passengers and also with the motorman.

Every car must have the following information clearly indicated on its exterior: 1, the owner; 2, the car number, and, in the case of passenger cars, this number must be placed once at each end and on each side; 3, on all cars, the weight of the car, including axles and wheels, and except such loose apparatus as may be needed for the equipment; 4, on freight and express baggage cars, the carrying capacity; 5, the time the last inspection was made. The interior and the platforms of passenger cars must contain a record, in addition to the car number, of the number and kind of seats in each compartment.

INSPECTION.—The electrical apparatus on motor cars must be inspected every six months. The entire car must be inspected throughout at least every two years and trail cars at least every three years. This form of inspection covers the raising of the car body from the trucks and the taking out of axles and bearings for testing their strength. Detailed reports must be made of such examinations and submitted to the inspecting officials. The date of this general overhauling must be marked on every car.

If cars are operated at more than 12½ miles an hour, the track must be inspected every day. At lower speeds the inspection must be made at least every three days. If the rails are in paved streets, the inspection periods will be prescribed by the official commission.

SPEEDS.—The maximum speeds of trains, as a rule, shall be 19 miles for lines having a gage of 4 ft. 8½ ins. or 3 ft. 3⅜ ins.; 15.5 miles for lines of 2 ft. 6 ins. gage; 12.5 miles for lines of 2 ft. gage, and 9.3 miles for rack railways. Higher speeds are allowed only with the permission of the Minister of Public Works, if it is shown that the traffic conditions justify them. The commission reserves the power to enforce lower speeds where the traffic is very heavy or there are severe grades; or these lower speeds may be changed for definite periods. The maximum speeds fixed are to be lower also at curves or other places where safety demands it.

OPERATION.—Cars must stop at crossings and connections of other street railways, unless there is a solid procession of soldiers, funerals, mail wagons or fire department trucks. Aside from switching and stopping places, trains and individual motor cars must be at least 65 ft. 8 ins. apart when traveling 10 miles an hour; 98 ft. 6 ins. when running at 12½ miles, 197 ft. at 15½ miles, and 328 ft. at 19 miles.

Motor cars standing on the track must be constantly in the care of one of the employees. The brakes must be applied, and on electric motor cars the controller handle must be removed.

The operation of a street railway can be suspended for longer than 24 hours by the local police with the consent of the commission only under the following conditions: (A) When work must be done on or under the streets which will prevent the running of cars. (B) When on account of festivals, public processions or other reasons an unusual number of people would cause blockades at certain parts of the line.

ACCIDENTS.—In case of accident, the management must conduct an examination to discover all the facts in the case and determine on the proper measures. Managers must make immediate reports of accidents involving death, or serious injury to persons, heavy damage to structures or rolling stock and of service interruptions greater than 24 hours. Smaller service interruptions and such accidents as involve no serious injury to persons or property, can be reported within such times as are set by the commission. The management of the railway company must keep a record of all accidents and traffic interruptions in the order of their occurrence, giving the time, place, cause, and what was done in relation thereto. Jacks and other tools useful in accidents should be quickly obtainable.

EMPLOYEES.—A record must be kept of all employees in outside service, including full name, age, place of birth, address, date of employment and discharge, and service number. This record must further contain a list of all penalties inflicted as discipline, together with other data which will show the technical ability and reliability of the parties in queston. These records must be submitted to the commission for inspection whenever demanded.

Including days of rest, no motorman must work more than a monthly average of 10 hours a day, and conductors and brakemen not more than 11 hours. Under simple operating conditions the average daily work may be extended to 13 hours. Under no circumstances shall one shift be longer than 16 hours. Working shifts of such length are only permissible when no hard work is required and there are several interruptions for rest. Every employee in the traffic service must have at least two holidays a month. Under simple operating conditions there need be only one holiday a month. A holiday shall be taken to mean an absence from service of at last 24 hours. The last condition may be modified somewhat on interurban railways with light traffic. The schedules for regulating the hours of work of all car service employees must be exposed in the offices of the management and placed before the commission on demand. The commission must also be informed at all time of the responsible managers of the railway companies, even where the change is for a very short period.

POLICE REGULATIONS.—Damage of street railway property, and anything that will interfere with the railway service is forbidden.

Heavy wagons or drays must not be driven on the track in a longitudinal direction if there is sufficient room between the sidewalk and the track.

When the warning signal is given by the car, all pedestrians, riders, drivers, cyclists and others must leave the track at once. This regulation does not apply to soldiers marching, funerals and similar processions, mail wagons and fire trucks.

When a car stops, all vehicles and persons on horseback must reduce speed to permit passengers to enter and leave the car without danger.

No one is allowed to board a car upon which the conductor has placed a sign indicating that the car is full. Cars must not be entered or left on the wrong side.

A LARGE HIGH-HEAD WATER POWER PLANT in Europe was put into service a few weeks ago. The Brusio power plant, in northern Italy, uses the power of the Poschiavino, a tributary of the Adda River. A supply conduit about three miles long conducts the water from a small lake in the upper course of the river to a headbay, whence five penstocks lead down to the powerhouse. The head obtained is about 1,375 ft. Six turbines of 3,000 HP. each are installed. They were built by Escher Wyss & Co., of Zürich, and by Piccard, Pictet & Co., of Geneva. Ultimately six more of the same size are to be put in, giving a final capacity of 36,000 HP. The polyphase current generated is raised to 47,000 volts pressure for transmission, the lines having an aggregate lngth of 100 miles. The power is utilized for an electric railway and for general supply in the territory north of Milan. The electrical machinery was built by the Alioth Co., of Basel.

RAILWAY ADMINISTRATION IN CAPE COLONY.—South Africa has been reported upon by a special commission appointed by the colonial governor, Sir W. F. Hely-Hutchinson. The railways are owned and operated by the government, and the commission states that it is impressed with the necessity of removing the management of the railways from the influence of party politics without lessening the legitimate control which must be exercised by Parliament as the representatives of the taxpayers. It recommends the formation of an advisory board, composed of four members of Parliament and four persons appointed by the governor (who may or may not be members of Parliament). The Commissioner of Public Works or the minister intrusted with the administration of the Railway Department would be chairman of the board. This board would advise the minister in regard to matters of general policy, rates and fares, works to be undertaken, expenditures and contracts. No proposal for a new line would be submitted to Parliament (or the legislature) unless first submitted to the advisory board and accompanied by a report of the board as to cost, revenue, traffic, etc. The board may recommend that the construction of new lines shall be conditional on contributions from the inhabitants and landowners specially benefited by such lines, the contributions being toward (A) cost of construction, (B) maintenance and operation, (C) interest on capital.

DIAGRAMS FOR PROPORTIONING REINFORCED CONCRETE BEAMS.

(With Diagrams on Two-Page Inset Sheet.)

A compact diagram for facilitating the design of reinforced-concrete beams has been drawn up by Mr. A. H. Perkins, Engineer in the U. S. Reclamation Service at Huntley, Mont. It is a compound diagram, comprising (1) a set of lines giving the bending moment in a simple beam for any span and any load per foot of length and per inch of width; (2) a set of lines giving the corresponding values of breadth and depth of reinforced-concrete beam to resist this moment. This latter part of the diagram is based on the following unit values:

c = maximum compression in concrete = 600 lbs. per sq. in.

s = tension in steel = 12,000 lb. per sq. in.

$n = E_s \div E_c = 10$

p = percentage of steel = 0.95%.

M = moment capacity of beam b inches wide, and d inches deep,

$$= 100\ bd^2.$$

The stress-strain curve of concrete is assumed to be between the straight line and the parabola.

The diagram is used as follows: [Referring to Fig. 2 on the supplement sheet]: The main horizontal scale of the diagram, figured along the base, reads Moment in inch-pounds. One of the vertical scales along the left, figured to w = uniformly-distributed load on beam per foot of length and per inch of width, in pounds, is to be used in connection with radial lines on the diagram representing various span-lengths, from 5 ft. to 30 ft. Any unit-load, as 30 lbs., carried horizontally to intersection with the actual span-length, as 12 ft., gives an abscissa (read on the scale at bottom) showing the maximum bending moment, in this case 6,500 in.-lbs. A parabolic curve on the diagram enables one to read the depth of beam required for any moment; thus, following up the vertical through 6,500 in-lbs. to the curve and thence horizontally to the left, the vertical scale for h = total depth reads 9 ins. As shown by another vertical scale (for h — d), this 9 ins. allows for a depth of 1 in. of concrete below the center of reinforcement; that is, the effective depth required for the moment of 6,500 is 8 ins. Two horizontal scales along the top, in conjunction with a series of hyperbolic curves across the diagram, give the required size and spacing of reinforcement. The two scales are for round rods and square rods, respectively. Thus, the 9-in. beam in question, if reinforced with ½-in. square rods, would require them to be spaced about 3¼ ins. apart. Finally, a fourth vertical scale gives the weight of beam per foot of length and per inch of width; in this case it is 10 lbs.

The diagram Fig. 3 is exactly the same as Fig. 2, but is drawn on a much smaller scale, so as to have a larger range. It covers spans up to 40 ft., depths of beam up to 52 ins. (48 ins. effective depth) and moments up to 300,000 in-lbs. per inch of width.

Example 1—Required a beam to resist a moment of 1,200,000 in-lbs. Choose the width of beam, say 12 ins. Then the moment per inch of width is 1,200,000 ÷ 12 = 100,000 in-lbs. Follow the vertical from 100,000 on bottom scale (Fig. 3) to the moment curve, thence horizontally to left, and read 34½ ins. As shown by the scale for (h-d), this depth allows 3 ins. of concrete below center line of reinforcement. The reinforcing rods, if 1-in. rounds are used, should be spaced 2½ ins.); if 1-in. square rods, 3¼ ins.; that is, five 1-in. rounds or four 1-in. square rods would be sufficient.

Example 2.—A floorbeam spanning 12 ft. carries a floor panel 6 ft. wide, whose live-load is 80 lbs. per sq. ft. and dead-load about 20 lbs. per sq. ft. The load per running foot of beam therefore is 600 lbs. Take the weight of the beam, for trial, as 80 lbs. per ft., giving a total load of 680 lbs. Assume a beam 10 ins. wide; then the load per inch of width is 68 lbs. On Fig. 2 find 68 in scale of w, follow horizontally to intersection with diagonal marked 12 ft., thence vertically to moment-curve, thence horizontally to left, reading 13½ ins. depth, with 1-in. of concrete below center of rods. The weight of the beam per foot is 14½ lbs. × 10 = 145. This is more than assumed. Recalculate with a total load of 600 + 150 = 750 lbs., or assuming a width of 10 ins., 75 lbs. per inch. The required depth is 13¾ ins. when h-d. is 1-in., or 14 ins. when the rods are 1¼ in. above the bottom of concrete. The weight, 15 lbs., is the same as was assumed. Five ½-in. square rods (spacing 2 ins. for ½-in. square rods) are the reinforcement.

In the diagram Fig. 3 the rays representing span-lengths are shown heavy where the vertical end-shear exceeds 50 lbs. per sq. in., and light where the shear is less than 50 lbs.

A DIAGRAM FOR OVERTURNING MOMENTS ON RETAINING WALLS FOR EARTH OR WATER.

(With Diagram on Two-Page Inset Sheet.)

A graphical solution of the Rankine retaining-wall formula is given by a diagram printed on the supplement sheet of this issue. It gives by a single reading the overturning moment, for any height of wall from 6 ft. to 50 ft., for earth of any weight from 10 to 120 lbs. per cu. ft. and various slopes of repose from 1 on 1 (45° with horizontal) to 1 on 4 (14° with horizontal), or for water at 62.5 lbs. per cu. ft. It is a complete

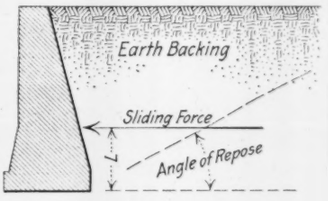


Fig. 1.

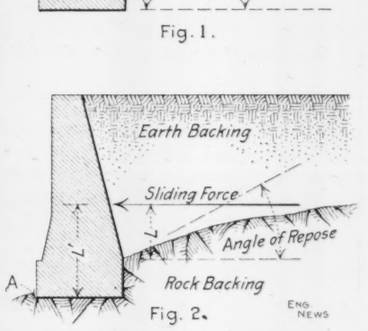


Fig. 2.

substitute for computation in most cases of retaining wall design or analysis, and in all other cases it can serve as a useful check on calculation. The diagram was constructed by Mr. Charles H. Hoyt,* late Assistant Engineer in the State Engineer's Department, Albany, N. Y., and has been found by him to be a great time-saver in the large amount of retaining wall work required in connection with the New York State Barge Canal.

The diagram solves the formula

$$M = P\frac{H}{3} = \frac{1}{2} w H^2 \frac{1-\sin\phi}{1+\sin\phi} \times \frac{H}{3} = \frac{1}{6} w \frac{1-\sin\phi}{1+\sin\phi} \times H^3 = C H^3$$

where

M = overturning moment at base of wall, in foot-pounds.

H = height of wall, in feet.

P = total horizontal thrust against wall.

w = weight of backing, in pounds per cubic foot.

ϕ = angle of repose of backing, or angle between surface of natural slope of backing and horizontal.

The horizontal and vertical scales of the diagram are, of course, logarithmic, which enables straight lines to represent the individual factors of the formula. The main horizontal scale represents overturning moments, the vertical scale represents the factor C. As the quantities involved number more than three, two graphical operations are required, and these are combined in the one diagram by the help of a second horizontal scale, the scale of w, at the bottom. The auxiliary scale is used in conjunction with diagonal lines inclined downward to the right, extending across the diagram, and representing individual values of slope of repose. Diagonal lines sloping upward to the right represent heights of wall. The slopes of repose are expressed not in degrees, as is often done, but in the form of "one (vertical) on x (horizontal)," in the same way as side slopes of ditches and embankments are currently described.

The intersection of the vertical line through any value of w, weight of earth, with a diagonal for any specified value of slope of repose determines a horizontal line whose height above the base is C in the formula $M = C H^3$. The multiplication of C by H^3 is accomplished by following the C-line horizontally to an intersection with the appropriate H-diagonal; the abscissa of this intersection, read by following vertically to the top scale of the diagram, gives the desired overturning moment. When the thrust is wanted, it can of course be found from the moment by dividing the moment by one-third the height of wall.

Mr. Hoyt gives the following illustrative examples.

1. Wall 28 ft. high, backed with earth assumed to weigh 90 lbs. per cu. ft., slope of repose 1 on 1½. What is the overturning moment at base, and the sliding force? Find w = 90 on auxiliary scale along bottom, and follow the heavy dash line vertically to intersection with diagonal marked 1 on 1½. Thence follow horizontally to intersection with line marked H = 28.0, thence vertically to top and read M = 94,000 ft.-lbs. per lin. ft. of wall. The moment arm (Fig. 1 on this page) is $L = \frac{1}{3} H = 9\frac{1}{3}$ ft., hence the sliding force is 94,000 ÷ 9⅓ = 10,070 lbs. per lin. ft. of wall.

2. If the wall were a dam, required to retain water 28 ft. deep, what would be the moment at the base and the total thrust? Follow the horizontal marked "Water at 62.5 lbs." to intersection with diagonal "H = 28.0," thence vertically to scale at top and read M = 229,000 ft.-lbs. per lin. ft. The thrust is 229,000 ÷ ⅓ 28 = 24,500 lbs.

3. Case where toe of wall is below bottom of earth backing (Fig. 2). Wall 22 ft. high, nothing in front, solid rock 4 ft. high at back, 18 ft. of earth backing above, weighing 90 lbs. per cu. ft. and having a slope of repose 1 on 1½. Follow vertical line from w = 90 to slope line for 1 on 1½, thence horizontally to H = 18.0, thence vertically and read M = 25,000 ft.-lbs. This is the moment at a level 4 ft. above base of wall. As there is no additional thrust below this point, the moment at base A will be

$$25000 \times \frac{L'}{L} = 25000 \times \frac{6+4}{6} = 41{,}670 \text{ ft.-lbs.}$$

*Civil Engineer and Superintendent of Construction, Fort Warren, Boston Harbor, Mass.

MOSQUITO PREVENTION BY DITCHING and draining the Hackensack Meadows, west of Jersey City, is being carried on under the direction of Prof. John B Smith, Entomologist of the New Jersey Agricultural Experiment Station, New Brunswick, N. J. The work now in hand was begun about April 10 and it is expected that it will be completed by May 15. Hand labor was used at the start, but it was expected that ditching machines would be employed by the end of the second week of the work. At our request, Prof. Smith has outlined the work as follows:

Our object in this ditching is to relieve the meadows of surface water. For that reason we make our ditches approximately 30 ins. deep and from 10 to 12 ins. wide, with steep sides. These ditches run into the clay or mud and do not grow up from the bottom. They drain at all tides and almost immediately lower the surface water table from 6 ins. to 1 ft. This is sufficient to get rid of the great bulk of the breeding places on the meadows. The larger pools that are deeper than 1 ft. are either directly connected with the ditches so as to admit fish, or they are filled with the sods taken from the ditches. The total area to be drained is approximately 640 acres and the amount of ditching provided for is about 115,000 ft.

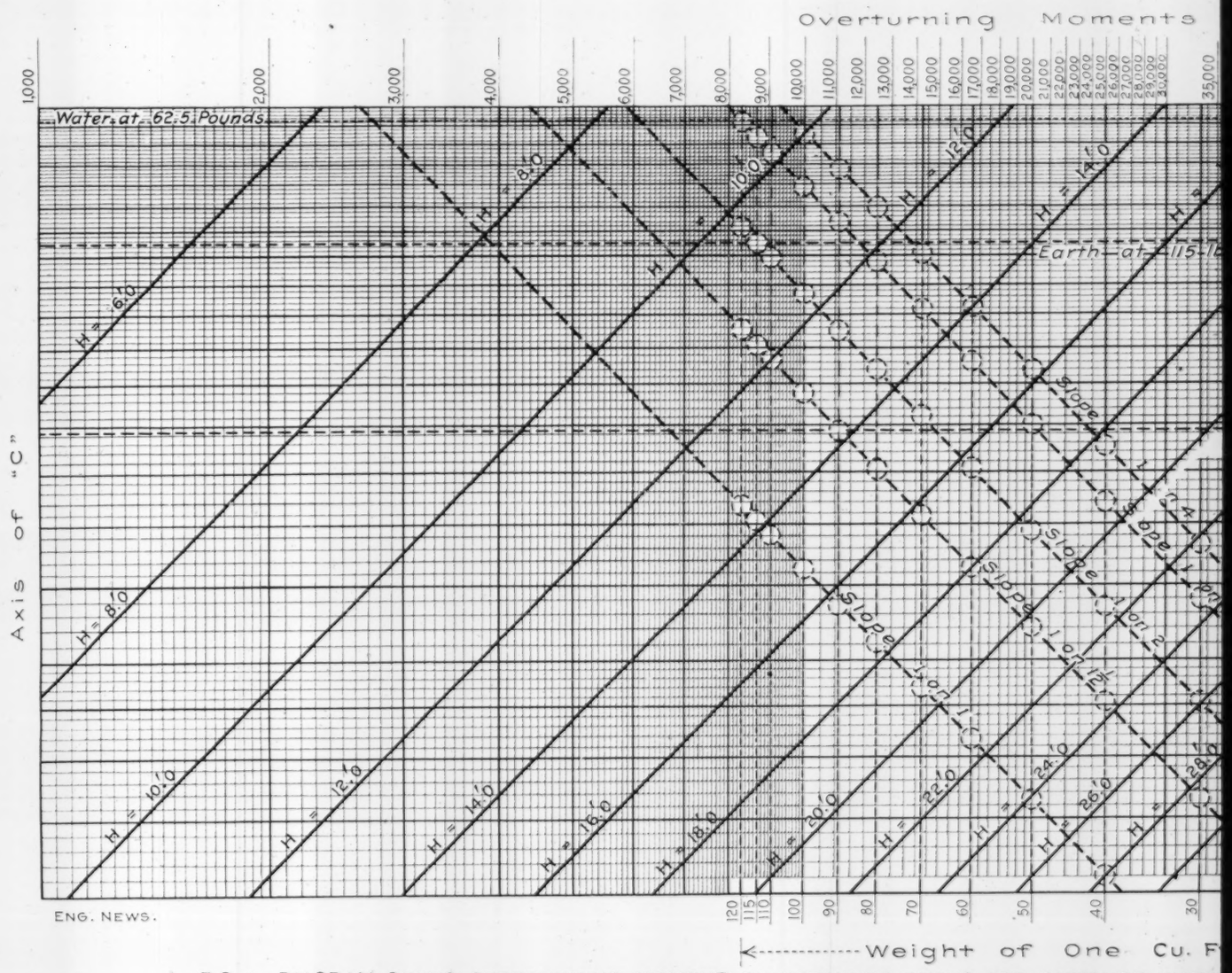


FIG. 1. DIAGRAM GIVING OVERTURNING MOMENT ON RETAINING WALLS FOR EARTH OR WATE

Based on Formula $M = \frac{w H^3}{6}$

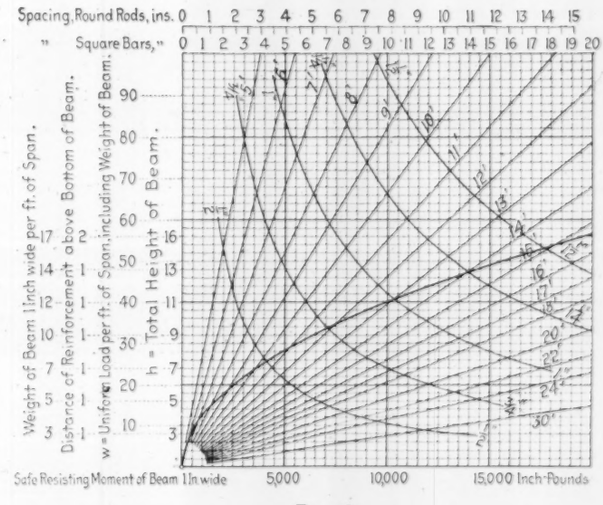

Spacing, Round Rods, ins.
" Square Bars, "
Weight of Beam 1 inch wide per ft. of Span.
Distance of Reinforcement above Bottom of Beam.
w = Uniform Load per ft. of Span, including Weight of Beam.
h = Total Height of Beam.
Safe Resisting Moment of Beam 1 In wide
5,000
10,000
15,000 Inch-Pounds

Fig. 2.

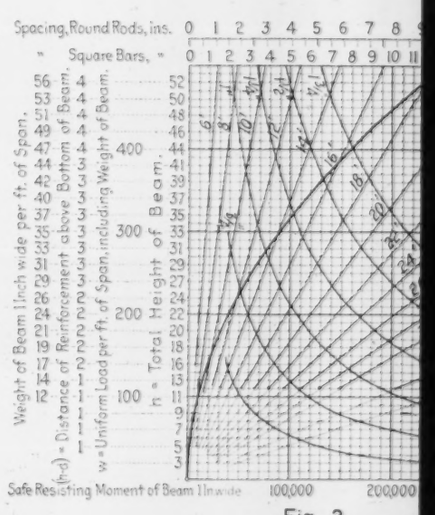
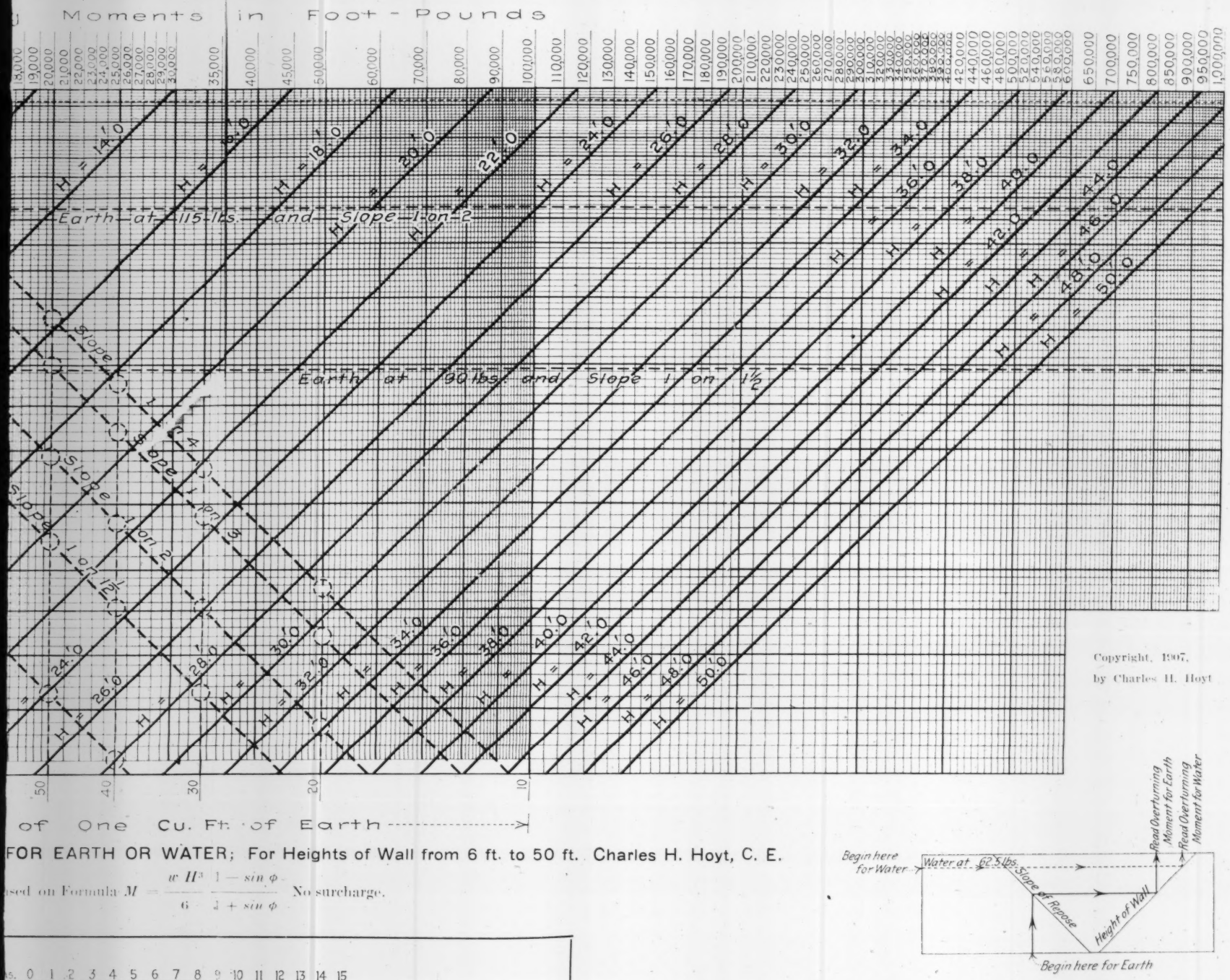

Spacing, Round Rods, ins.
" Square Bars, "
Weight of Beam 1 inch wide per ft. of Span.
Distance of Reinforcement above Bottom of Beam.
w = Uniform Load per ft. of Span, including Weight of Beam.
h = Total Height of Beam.
Safe Resisting Moment of Beam 1 In wide
100,000
200,000

Fig. 3.

DIAGRAMS FOR PROPORTIONING REINFORCED CONCRETE BEAMS. A. H. Perkins, Huntley


y Moments in Foot-Pounds
Earth at 115 lbs. and Slope 1 on 2
Earth at 90 lbs. and Slope 1 on 1½
of One Cu. Ft. of Earth
Slope
Copyright, 1907,
by Charles H. Hoyt

FOR EARTH OR WATER; For Heights of Wall from 6 ft. to 50 ft. Charles H. Hoyt, C. E.

Based on Formula $M = \frac{w H^3}{6} \frac{1 - \sin \phi}{1 + \sin \phi}$ No surcharge.

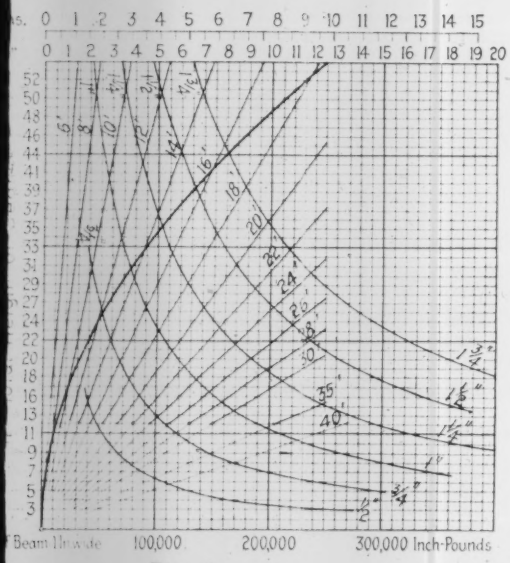


Fig. 3.

A. H. Perkins, Huntley, Mont.

Begin here for Water
Water at 62.5 lbs.
Slope of Repose
Height of Wall
Read Overturning Moment for Earth
Read Overturning Moment for Water
Begin here for Earth

Directions

For Water Pressure.—Follow horizontal line marked "Water at 62.5 lbs." to intersection with H-diagonal corresponding to the height of the wall in feet. Follow vertically to top and read overturning moment in foot-pounds.

For Earth Pressure.—Knowing the weight per cubic foot of the earth in the case, find this value on the scale along the bottom of the diagram. Follow vertically to the Slope-diagonal marked with the slope of repose appropriate to the case. Thence follow horizontally to the H-diagonal marked with the height of the wall in feet. Thence follow vertically to top and read overturning moment in foot-pounds.

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ADVERTISING

"Contract": Rates furnished on application.
"For Sale": $1.50 per inch.
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Entered at the New York Post-Office as Second-Class Matter.

The dedication exercises last week of the splendid new Engineering Societies Building in New York City constituted an event worthy of prominent record in the annals of the engineering profession.

Those who took part in these exercises emphasized the fact that even more important than the building itself is the harmony and cooperation between engineers and between different branches of the engineering profession, of which the building may truly be said to be at once the result and the expression.

The history of the movement which brought about the construction of this building is familiar to many of our readers; but some of the main facts in connection with it are well worth rehearsing. Half a dozen years ago it seemed likely that each of the four national engineering societies would build its own separate house as a national headquarters in New York City. The Electrical Engineers' Institute particularly, which had always occupied rented offices, was ripe for a movement looking to the establishment of proper quarters and a place for its valuable library. The Mechanical Engineers had wholly outgrown their old house on 31st St.; and in the American Institute of Mining Engineers a desire for a new and fitting house was often heard.

Such independent action seemed to us and to many of the foremost men in all the different engineering societies, a result to be greatly deplored. It meant the collection of contributions from engineers for four separate buildings instead of for one and a perpetual tax on engineers the country over for the care and maintenance of four separate headquarters.

With the financial limitations which such a division of forces would involve, it was clear that none of the buildings could be made nearly as adequate for the society's needs as would be possible if the several societies were to unite their forces and financial strength.

The desire for cooperation between the engineering societies for the end thus outlined was voiced by many engineers; but by none more eloquently and effectively than Mr. Chas. D. Scott, of Pittsburg.

Some of our readers may recall the notable dinner at the Union League Club in Philadelphia four years ago in celebration of the twenty-fifth anniversary of the Engineers' Club of Philadelphia. Mr. Scott was one of the guests at that dinner, and in speaking to the toast "The Twentieth Century Engineer," he used the following words:

> Methinks I see the outlines of a magnificent building, the Capitol of American Engineering. Into this home, situated in the metropolis of the nation, are gathered the great engineering societies from their scattered lodgings. Here is a great technical library; here are ample assembly halls and comfortable parlors; here are the headquarters of a score of lesser societies, restricted in their scope, but affiliated in their work.

This ambitious ideal was destined to be realized. A few weeks later occurred the annual dinner of the American Institute of Electrical Engineers, of which Mr. Scott was then President; and at that dinner he again voiced the wishes of the engineering profession for a worthy home. Mr. Andrew Carnegie was one of the guests at that dinner and on the following day he sent for Mr. Scott and Mr. Calvin W. Rice, chairman of the Building Committee of the Institute, conferred with them on the needs of the societies, and a few days later formally expressed to a party of engineers, representing all the different societies, his willingness to provide the money for a great building to accommodate all the engineering societies.

This work has now been accomplished. On a plot of ground 125 ft. in frontage and extending through from 39th St. to 40th St., there have been erected two splendid buildings, one for the Engineers' Club, a purely social organization, facing on 40th St., and one for the national engineering societies, on 39th St. The latter building, dedicated last week, is 14 stories in height and has cost $1,050,000, contributed by Mr. Carnegie. The land on which it stands has been purchased by the three national societies to which the gift was made at a cost of $540,000. The Engineers Club also purchased the land for its building, which is to be formally opened during the present week, and its gift from Mr. Carnegie was the sum of $450,000.

Elsewhere in this issue we show views of the building and of its interior; but no printed pictures or description can give the reader an adequate impression of the building and its appointments, and no account of the dedication ceremonies can adequately portray the dignity and impressiveness of the occasion.

The point which we would emphasize and which was again and again made clear in the various addresses, is that this magnificent building stands for the benefit of the engineering profession. With praiseworthy breadth and liberality, the three great national societies which accepted the gift from Mr. Carnegie are administering it as a trust. The great library to which the upper part of the building is devoted, for example, is open to the free use of any engineer. It comprises the libraries of the three founder societies and will doubtless be so added to as to shortly become the most complete and useful engineering library in the United States, if not, indeed, in the world.

The building itself has already become the headquarters not only of the founder societies, but of nearly all the other national engineering societies which have offices in New York and of the local engineering societies of New York City as well. The total membership of the societies having headquarters in the building can hardly fall short at the present time of fifteen thousand.

The review of available evidence regarding natural ice as a disseminator of typhoid fever, printed elsewhere in this issue, should do much to direct attention to the real dangers besetting ice users. These lie far more in the distribution of the ice and its subsequent handling and use within homes and offices than in its production and harvesting in rivers, ponds and lakes. The very few recorded outbreaks of disease of any kind directly attributed to ice, the fact that all of the half dozen outbreaks on record embrace only a few score of people, most of whom had ill-defined intestinal disorders, and the unsatisfactory character of the evidence in some of the outbreaks, all combine to give great force to the opening paragraphs of the paper, in which the long-continued persistency of "solidified [sanitary] delusions" is pointed out. If only the public could be taught to fear real instead of imaginary dangers sweeping sanitary reforms would be effected in short order.

The annual publication of the Pennsylvania R. R. Co. giving in detail the mileage of the system at the close of the calendar year, shows a grand total of 23,109 miles of track in the system on Dec. 31, 1906. This is substantially one-thirteenth of the mileage of railroad track in the whole United States. A better idea of the importance of the Pennsylvania system is afforded by the fact that over 12,000 miles of this track is additional tracks and sidings. Of the total mileage of second, third and fourth track and sidings, in the United States, one-seventh is included in the Pennsylvania system.

The total main track mileage of the Pennsylvania, 10,977 miles, is exceeded now by the aggregation known as the "New York Central Lines," and also by the combined Union Pacific and Southern Pacific systems; the latter combination, however, ranks far below the Pennsylvania in total mileage of tracks.

It is of interest to note that what are classed for want of a better name as "company sidings" but which might, perhaps, be better described as yard tracks, now nearly equal in extent on the main lines of the system, the main track mileage itself.

It has been frequently pointed out that the development of the railway and the growth of great cities which have been such important features of the last half century have resulted on the one hand in reducing the cost of freight transportation between terminals to a figure surprisingly low, while on the other hand the cost of handling at terminals has steadily increased. The bigger and more complicated the system of yards at a great terminal, like Chicago or New York, the more slow and expensive the work of sorting and marshalling freight cars and delivering them to the proper point. It appears probable from the figures quoted in the publication before us that the terminal and division yards on the Pennsylvania's main line contain enough rails to lay a single track over its road from New York to Chicago.

What are the ethics governing correspondence with applicants for an advertised position? A correspondent complains that letters sent in reply to a "situation open" advertisement have not been answered. It is probable that his experience is not an unusual one; but the question recurs why the man who offers to sell his services should not be treated with the same courtesy as the man who sells iron or cement or steam engines. Perhaps the answer may be made that the situation hinges largely on the respective number of letters involved. If the man who wishes to buy an engine receives letters from thirty or forty dealers, he may not take the trouble to answer them all any more than he does the thirty or forty applicants who apply for a position as an engineer.

We believe, nevertheless, that the man who answers a "situation open" advertisement is entitled to at least the courtesy of a reply when the matter is finally settled and the position in question is filled. He has at least the satisfaction then of knowing that his application received attention and he can make up his mind regarding other openings without any doubts or reservations respecting possible offers from this former place.

Another complaint which comes to us is that samples of work sent in response to a "situation open" advertisement have not been returned, even though return was specifically requested and postage for the return was sent. This is certainly a gross breach of business courtesy; but it is nevertheless common and the only safe plan is for an applicant to send to any party advertising under a nom-de-plume, copies only of testimonial letters, samples of work, etc., which can be duplicated if the necessity arises.

We commented last week on the disobedience of rules by railway employees which caused the fatal head collision at Fowler, Ind. Later in-

formation regarding the open switch disaster at Colton, Cal., in which nearly 30 persons were killed, showed that concurrent disobedience of rules by several employees was responsible for the wreck. An official of the Southern Pacific Co. informs us that the switch engine passed through the switch near the entrance of the Colton yard from five to ten minutes prior to the time the accident occurred, as nearly as could be determined by the investigation. The switching crew had no special orders governing their movements in the yard; they were working under the standard rules governing switching service, which provide that all main line switches must be locked immediately after they are used. The crew was informed as to the time the passenger train would arrive, and went out on the main line and used the switch which caused the derailment in the face of standing instructions to the contrary.

While this disobedience of orders was directly responsible for the wreck, the engine-runner of the express train also disobeyed orders requiring the reduction of speed within yard limits to 15 miles per hour. Had he maintained a proper look out, he would have seen the open switch in time enough to stop his train anyway, since the track was straight for three miles beyond the switch.

THE USE OF TABLES AND DIAGRAMS FOR PROPORTIONING REINFORCED CONCRETE MEMBERS.

A prominent engineer in a paper before an Engineering Society recently said that the day is fast approaching when the methods of computing reinforced concrete will be just as well standardized as the methods for steel structures. No one will deny that simplicity in design of all kinds is a desirable end. Few will claim that the formulas for the computation of reinforced concrete should be lengthened and complicated by numerous theoretical considerations which cannot be carried out in actual practice. Even as they stand these formulas are too complicated and unwieldy. But some of the attempts now being made to shorten and standardize these computations can hardly help toward a scientific development of concrete designing.

There has been during the past three years or so an extensive production of tables and diagrams for use in reinforced concrete designing; and many of them have been offered to us for publication. A few have already been presented to the profession in these columns, and in the present issue we give space to a considerable number of such diagrams for use in the design of retaining walls and of beams.

That such diagrams may be very useful to the designing engineer goes without saying, or they would not be presented in this journal; but it seems proper at this time to sound also a note of warning in connection with such diagrams. For very many of our readers, we know, the warning will be wholly unnecessary, but there are engineers who use a formula or diagram as the ignorant use the patent medicine to which they pin their faith, and the same cure is applied for all ills.

Speaking in a general way, it may be said that the diagrams made for stress analysis in reinforced concrete members are all computed on more or less rational bases, and claim to give the size required for safe strength for a certain kind of member under given assumed load. The position of the member in the structure, its relation to other members, the condition of its erection and ultimate use, all are assumed constant and the same for each size as figured. If the tables or curves are for beams the original formula, from which the curves or tables are figured, is computed under some accepted method, for a beam of certain span, cross-section and percentage of reinforcement, considered merely as a separate beam between two supports, restrained or free, and acted upon by vertical imposed loads. By means of curves so developed the sizes of another beam are computed. The beam to be designed may be intended to carry a street, where it is subjected to the repeated impact of wagon and car traffic; it may be over the hot chamber of a dry kiln; it may be at the bottom of a tank, entirely under water; it may, in fact, be in a hundred different places under totally different conditions from those of the beam on which the curves are originally based. In spite of the fact that the conditions of design, construction and use are different from the original beam there will be many men who will use the curves without study as to their applicability, merely because they are for the design of reinforced concrete beams.

In the past we have had occasion to comment on this blind adherence to formulas which have been in wide use for years, without preliminary investigations to determine the similarity of conditions between the foundations of the original formula and the problem at hand. For instance, in a plain section of masonry, subjected to eccentric vertical loading, the line of pressure must fall within the middle third to avoid tension or joint opening in the heel of the section. Yes; if this section is a solid rectangle, but the middle third theory does not hold for other than a solid rectangular section, the division is into some other fraction, varying with the shape of the section. Is this remembered by all engineers?

Similarly the proper selection of the various coefficients in Kutter's diagrams for the flow of water is a factor that makes those diagrams valuable and reliable. In fact, the knowledge of the limits within which a theory or formula can be relied upon is exactly as important as a knowledge of the theory or formula itself. The ability correctly to apply empirical constants is the distinguishing mark of the experienced engineer.

In this same direction lies the danger in published tables or curves for reinforced concrete design. They create an impression that a reinforced concrete unit can be designed purely for the load coming on it without regard to the peculiar conditions surrounding its erection or future use. That these varying conditions must affect the design is evident.

Illustrative of some points in specialized design, we noted in an editorial in our issue of March 21, 1907, the harmful effect of any cracks in reinforced concrete by which water can carry a stray current to the steel and cause much damage by electrolytic action. So, also, Mr. Hanna's paper on "Reinforced Concrete for Irrigation Structures," published in our issue of April 4, 1907, calls attention to the corrosive action of water entering into any cracks in concrete. This latter paper also notes other differences in reinforced concrete design in irrigation work, such as a thicker protecting face for the rods, larger size cross-section for reinforcement and the necessity for a close mechanical bond in the steel. It has never been proved that the minor and hair cracks in concrete work have any weakening effect on the strength of the structure, and in ordinary work, well protected from exceptional and protracted moisture and electric current, such cracks need give no great concern, aside from their unsightly appearance. But although it has been so far impossible to entirely eliminate this tendency to crack, it is quite certain that in structures exposed to water or electricity, the units should be so designed as to reduce it just as much as possible. It is just such details that are not cared for in the standard computations, but must be looked after by the individual designer.

Every specialized use of the material is bound to bring out some exceptions in design. The designer of buildings knows his formulas and dimensions, but whether they will apply to a beam exposed to temperatures of 300° F. remains to be discovered. As an aid to the designer's work, standardized curves and tables in any line are of great value; but the competent engineering knowledge—when and how to apply them—must always be at hand.

There is no danger in such tables to the experienced and careful designer. To the man who devises them they are invaluable. He knows the exact limit of his assumptions and can measure the bounds of their applicability. The danger lies in their use by the inexperienced and careless. The idea that reinforced concrete is an uncertain and variable mixture of some sand, a little cement and a few stones, the mass to be indiscriminately soaked with water and thrown into place, has altogether too wide a reach as it is. And when men holding such ideas come across tables purporting to give the exact size and reinforcement for *any* 20-ft. beam, the idea of extreme simplicity and ease of design is confirmed.

In the very laudable desire to put concrete design on a more scientific basis and to remove from it a great deal of the all too prevalent mystery it must be remembered that the material is not consistent as is steel, which acts in the same way under nearly all conditions, but that its behavior is to a large extent dependent upon its use. The idea that the load upon a beam constitutes all that is needful for its design can but lead to trouble. Standardized curves and tables which assume this are dangerous things in the hands of a hurried, a careless or a poorly-informed engineer.

LETTERS TO THE EDITOR.

Patents on Caisson Tunneling.

Sir: In your issue of April 11 you have an interesting account of the method of making the joints in the tunnel under the Seine. This method is covered by patents in this country and Canada, which have been issued to me, in January, 1903, and March, 1905, in the United States, Nos. 784,816 and 838,821, and October, 1905, in Canada, No. 95,419.

Yours respectfully,
T. Kennard Thomson.

Park Row Bldg., New York, April 15, 1907.

A Method of Scaling Earthwork Quantities from a Profile.

Sir: Referring to the letters in your issues of Feb. 28 and March 28, 1907, in regard to the "Quantity Scale" for estimating earthwork quantities:

I have used the "Quantity Scale" in railroad and irrigation canal work for several years, but find it much more saving in time if constructed with figures for even intervals of 100, 200, or 300 cu. yds. with corresponding scale lines plotted at proper points on vertical scale instead of placing odd yardage figures to correspond to even feet on the vertical scale, as shown in the examples in the other letters.

Yours very truly,
C. M. Arnold,
City Engineer.

Lethbridge, Alberta, Canada, April 9, 1907.

The Concrete Arch Proposed for the Hudson River in 1885.

Sir: On page 427 of your issue of April 18, 1907, you mention a design by the late Thomas C Clarke for a reinforced concrete arch bridge over the Hudson River in 1885.

His plan was a beton-coignet cellular (cross-section) arch, without any metal reinforcing.

Theodore Cooper.

45 Broadway, New York, April 18, 1907.

[The basis for our statement that the arch was "reinforced slightly" was the following extract from a letter from the late Mr. Clarke:

The tension in the soffit of the arch at the center and in the top of the haunches only was to be resisted by iron beams built into the concrete.

This, of course, would not warrant describing the bridge as "reinforced concrete."—Ed.]

Expansion Joints in Concrete Basement Floors.

Sir: Your issue of April 11 contains an inquiry as to whether it is customary to put in concrete basement floors monolithic or "blocked off."

The writer has laid approximately 75,000 sq. ft. of "blocked off" concrete basement floors during the past three years in rooms varying in size from 10 × 10 ft. to 100 × 40 ft., and they are all in perfect condition. The work was done during the summer and fall when no artificial heat was necessary. The subgrade of the floor was thoroughly tamped. Upon this was placed a layer of 1:3:5 concrete 3 ins. in thickness, and a finishing coat of 1:2 cement mortar 1 in. thick was placed upon the concrete before it began to set.

The dampness in the basements due to new plaster, condensation, etc., was sufficient to supply the necessary moisture during the period of hardening.

Yours very truly,

Flushing, N. Y., April 14, 1907. W. C. F.

Sir: Replying to an article in your issue of April 11, by E. D. Covell, relative to concrete basement floors, I wish to say that I have had charge of the building of a great many floors laid with 4 or 5-in. concrete sub-floor mixed 1:3:6 with a 1 in. top coat mixed 1:1½.

Some of these floors were laid solid and some blocked off and in almost every case where the floors were laid solid, cracks have appeared varying from 3 ft. to 8 ft. apart. Where the floors were blocked off into sections there has not been a single case under my observation where the floors have shown the slightest signs of cracking.

The method employed was to lay a section of concrete and then put on the top coat before the concrete had time to set, thus insuring a perfect bond, the joints being made after the surface was finished and driven to a depth of 3 ins. below the surface and dividing the floor into 3 ft. square sections.

The jointing tools consist of a bevelled plate about 18 ins. long and a brass jointer for smoothing the joints.

Very truly yours,
Frank A. Greene.

Woonsocket, R. I., April 13, 1907.

Concrete vs. Iron Pipe Culverts.

Sir: In your issue of Dec. 20, 1906, there is an article on concrete pipe culverts, by Mr. O. P. Chamberlain. This article gives estimated costs of concrete pipes as compared with cost of cast-iron pipe. The writer notes that the figures given for cost of cast-iron pipe appear to be in error. The cost of such pipe in our Eastern market is only about half that given by Mr. Chamberlain.

A. W. Carpenter.

New York, N. Y., April 2, 1907.

[The article in question was a reprint of an advance copy of a paper presented before the Western Society of Engineers. We are informed that a mistake was made in the prices assumed for cast-iron, and that the estimates were afterwards corrected. We give below the estimated costs, with the corrected figures, as they appear in the February number of the "Journal" of the Western Society of Engineers.—Ed.]

Size and kind of pipe.	Thickness, ins.	Weight per lin. ft., lbs.	Cost per lin. ft.
12-in. cast-iron.....	33/64	75	$1.22
12-in. concrete.....	2	88	0.16
18-in. cast-iron.....	47/64	167	2.72
18-in. concrete.....	3	220	0.36
24-in. cast-iron.....	1	250	4.07
24-in. concrete.....	4¼	420	0.68
30-in. cast-iron.....	1 1/16	334	5.43
30-in. concrete.....	4½	602	0.88
36-in. cast-iron.....	1⅛	450	7.32
36-in. concrete.....	4¾	676	1.10
42-in. cast-iron.....	1¾	600	9.75
42-in. concrete.....	5¾	960	1.55
48-in. cast-iron.....	1 7/16	725	11.78
48-in. concrete.....	6	1,131	1.83

Taking Contours on Preliminary Surveys.

Sir: My method of taking contours on preliminary surveys is, I think, more simple and accurate than any I have seen described.

The slopes are taken with a hand level and rod by a topographer and one rodman if the distances are paced or two rodmen if they are measured.

The elevations are procured from the level book each evening for the next day's work and are recorded on the center line of the topography book, space being left for any intermediates that it may be necessary to take.

The work in the field is as follows: If at station 200 the elevation is 422° and 5 ft. contours are required, the topographer would take a reading at the station. The rodman would then pace out at right angles to the line until he found a point 2 ft. below the station or elevation 420. He would then move again until he reached a point five feet below this last point, or elevation 415, and so continue as far as the topography was required. The other side of the line would be treated in like manner, starting from the center line. The total distance from the center line is recorded at each point.

This reduces the work in the office to a minimum. The notes taken at station 250 as above would read as follows:

440	435	430	425	Sta. 250.	420	415	410	405
350	200	100	40	El. 422°.	125	200	315	350

In platting the draftsman has simply to place his scale on the map and prick off the distances on both sides of the line from the book without removing the scale from the paper.

E. J. O'Connor.

Fort Bragg, Mendocino Co., Cal., April 3, 1907.

Retempering Mortar Made With Mixed Lime and Cement.

Sir: On a piece of work which we are constructing, specifications call for brick to be laid in lime mortar, with the addition of one sack of cement for each barrel of lime used. Now, on account of rains, or other causes, there is occasionally a quantity of mortar left over night that has already had the cement added to it, and the question has arisen as to whether or not this mortar is equally good for use the next day, providing an additional amount of cement is mixed in so as to make the fresh cement used of the proper proportions, as called for by the specifications.

We believe that no one will question that lime mortar left over night, or for any length of time, so long as it doesn't dry out, is uninjured for use. The amount of cement used does not produce any material effect upon the setting of the mortar when left over night, and there is no trouble to mix it up again with a hoe, and add a new lot of cement.

Is there any reason to suppose that the mortar remixed in this manner is not fully equal to the mortar made by mixing in the cement the first time? If you can give advice upon the matter through your columns, the same will be of value.

Respectfully,
Bartlett & Kling.

Cedar Rapids, April 12, 1907.

[We should think the opinion of one competent inspector on the ground would be worth that of two engineers elsewhere. If the mortar does not set at all over night, the retempering with the additional cement named ought to make a product at least as good as the mortar made with one sack of cement to the barrel. If anyone can quote experience to the contrary, we should be pleased to hear from them.—Ed.]

Specifications for Oak Ties.

Sir: I would like to have your opinion or that of any of your readers as to what is known as a "No. 2 oak tie," and refer you to an incident that happened lately to a contractor. The specifications for tracklaying called for a No. 2 oak tie to be furnished; but did not call for any particular kind of oak (such as white or red oak). The contractor furnished a quantity of each, or in other words mixed oak without taking into account the proportions.

One of the railway officials found fault with this, saying that a No. 2 oak tie in his opinion meant white oak and the No. 2 meant size only. The contractor claimed that No. 2 had only reference to size, and if any particular kind or quality was wanted it should have been specified. Not being so specified he fulfilled his contract by furnishing mixed oaks as mentioned above.

The size of tie furnished in this case was a hewed tie 6 × 6 ins. and 8 ft. in length, or when sawed ties were furnished they measured 6 × 8 ins., 8 ft. long. The engineer for the railway had a man inspect the ties before shipment or while being unloaded at the works. All ties that did not come up to the above measurements or had wind shakes or any other defects were rejected. He did not raise any question as to their being red or white oak, but would not take chestnut or any other timber. Who was at fault, the contractor or the railway official?

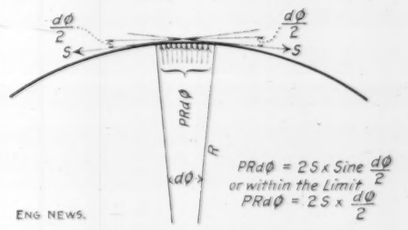
"Subscriber."

[This appears to be a case in which the specifications were at fault through not being sufficiently definite. If they simply called for "No. 2 oak ties" it is an open question whether size, species or quality was intended. The term "second class tie" as applied to ties for inferior lines and side tracks usually includes those of inferior quality and not conforming strictly to the sizes required for main track ties. The tie committee of the Railway Engineering and Maintenance of Way Association at the recent annual meeting proposed smaller sizes of ties for "No. 2 tracks," that is, tracks carrying a certain amount of traffic (under the classification adopted by the Association). This action was not approved at the meeting. Since both white and red oak were accepted by the engineer if they conformed to the specified size, it would appear that the term "No. 2" in the specifications applied to size and not to species. Local usage might have a bearing on the matter. A tie 6 × 6 ins. would certainly be of a second class character, and not adapted to main track. Very many roads use ties 6 × 8 ins. for main track, but there is a strong and growing impression that for main tracks carrying heavy traffic the thickness should be 7 ins.; this latter thickness is, in fact, already in extensive use under such conditions.—Ed.]

Solution of a Rope-Drive Problem.

Sir: Referring to the rope-drive problem submitted by Mr. O. Grimm, of Chicago, and published in your issue of April 4, 1907, I offer the following solution, which I trust will be of aid to Mr. Grimm and incidentally may interest such readers as have noticed his communication:

Let S be the tension at any point in the rope, and dS its increment in the small arc $R\,d\phi$. Let f be the coefficient of friction developed between the rope and the



drum. Let p be the intensity of the normal pressure of the rope on the drum in the small arc $R\,d\phi$. Then,

$$p\,R\,d\phi\,f = dS$$

But as the figure shows, for a small arc,

$$p\,R\,d\phi = S\,d\phi$$

so that by substitution we have

$$f\,d\phi = \frac{dS}{S} \quad \ldots\ldots\ldots\ldots (1)$$

or

$$f\,\phi = \int \frac{dS}{S} = \log_e S + C$$

When $\phi = o$, $S = S_1$, the initial tension in the rope. Therefore, $C = -\log_e S_1$, and

$$f\,\phi = \log_e S - \log_e S_1 = \log_e \frac{S}{S_1}$$

or, changing to common logarithms,

$$\frac{1}{2.3026}\,f\,\phi = \log \frac{S}{S_1} \quad \ldots\ldots\ldots\ldots (2)$$

ϕ being expressed in circular measure.

Applying eq. (2) to the problem as stated by Mr. Grimm, we have $S = 6{,}000$ lbs., $S_1 = 400$ lbs. (half of 800 lbs.), and by scaling from the sketch the angles which the projections of the haulage and tail ropes make with the plane through the axes of the drums we obtain a value for ϕ of $8\,\pi \div \frac{45}{180}\,\pi \div \frac{60}{180}\,\pi = 8^7/_{12}\,\pi = 26.9654$. Substituting these values in (2) we have

$$11.7108\,f = \log 15 = 1.17609,$$

or $f = 0.1004$ and $f\,\pi = 0.3154$.

Beginning now with the tail rope, the arc of contact on the first drum is (by scale) $\frac{1}{3}\,\pi$, and $\frac{1}{3}\,\pi\,f = 0.1051$. By eq. (2) we have, substituting this value

$$\frac{0.1051}{2.3026} = \log S_2 - \log 400 \quad \ldots\ldots\ldots (1)$$

From this by help of a table of logarithms we find S_2, the tension in the rope along the first pass between the drums, to be 444 lbs. Since the drums are equal in size, the next arc of contact is 180° or π, and substituting in eq. (2) as before we get

$$\frac{0.3154}{2.3026} = \log S_3 - \log 444$$

from which S_3, the tension in the second pass between the drums, is found to be 600 lbs. By the same method we obtain the following:

S_4 =	835 lbs.	S_8 =	2948
S_5 =	1145 "	S_9 =	4041
S_6 =	1569 "	S_{10} =	5540
S_7 =	2150 "	S_{11} =	5994

A little more refinement of calculation would have resulted in $S_{11} = 6{,}000$ lbs.

By combining the tensions above found we obtain the total thrusts between the drums in the plane of their axes as follows:

Resultant thrust on the drum nearest the tail rope $= S_2 + S_3 + S_4 + S_5 + S_6 + S_7 + S_8 + S_9 + S_{10} - S \cos 60°$ (scaled angle) = 18998 lbs.

Resultant thrust on the second drum $= S_2 + S_3 + S_4 + S_5 + S_6 + S_7 + S_8 + S_9 + S_{10} - S_{11} \cos 45°$ (scaled angle) = 16281 lbs.

While the writer has never seen a similar problem solved just as above, yet Bovey's "Theory of Structures and Strength of Materials" has aided him in the solution as given.

Yours most respectfully,
A. C. Hough.

317 Ninth Ave., Homestead, Pa., April 6, 1907.

[Two other correspondents have sent solutions of the problem. They begin, however, by assuming a coefficient of friction, which necessarily leads to contradiction with the stated conditions of the problem unless the coefficient should happen to be chosen identical with that actually developed. The results found in the two solutions therefore differ from each other and from that found above.—Ed.]

THE EARTH SLIP IN THE FACE OF THE EMBANKMENT OF THE NORTH DIKE OF THE WACHUSETT RESERVOIR.

By CALEB MILLS SAVILLE,* M. Am. Soc. C. E.

On Thursday, April 11, a portion of the face of the north dike of the Wachusett Reservoir slid into the water, carrying with it the riprapping, gravel facing and the extreme top corner of the primary cut-off wall.

When the South Branch of the Nashua River was taken for a water supply for metropolitan Boston, and the great masonry dam built at Clinton to form the Wachusett Reservoir, a portion of the north side of the valley, beginning at a point 1,500 ft. above the dam and extending for about two miles, was found to be below the level of full reservoir.† After having carefully studied this problem theoretically, in the field, and by laboratory experiments, it was decided that the best solution was to build a dike composed of soil stripped from the bottom of the reservoir, with several cut-off trenches and a core wall filled with selected material well watered and rolled in 6-in. layers.

The general plan and a number of sections of this dike are shown by Figs. 1 and 2. In the lowest lands along the line of the dike two cut-off trenches were dug, having depths varying from 30 to 60 ft., with a width of 30 ft. at the bottom, and having side slopes of 1 to 1. By this means the gravel and coarser sands were removed down to a depth where a nearly impervious sand was reached. In places, when this material could not be reached readily by methods of excavation, triple lapped sheet piling 6 ins. thick, made of spruce planks, was driven to a maximum depth of 62 ft. below the bottom of the trench.

The primary cut-off trench and wall is 100 ft. thick, with 1 to 1 slopes resting on the main embankment, which was built of sand and gravel and excavated from the trenches. The main embankment was about 250 ft. thick at its base, in the maximum section. On the land side it has a slope of 1 to 1, on which rests the main cut-off wall mentioned above. On the water side this embankment has a slope of 2 to 1, in which, at Elev. 377, a berm about 30 ft. wide breaks the slope. This entire face was covered with a gravel layer about 5 ft. thick, measured at right angles to the slope. Above the berm and resting on it from a point 5 ft. above high water to a point 12 ft. below is a heavy belt of riprap, 10 ft. thick, to protect the embankment from the action of the waves. The greatest width of the dike is 1,930 ft. It contains about 5,862,000 cu. yds. of earth.

*With French & Bryant, Civil Engineers, Brookline, Mass.

†See Eng. News, March 7, 1895, for general description of the Wachusett Dam (there called Nashua Dam), and Eng. News, May 8, 1902, for further details of the dike.

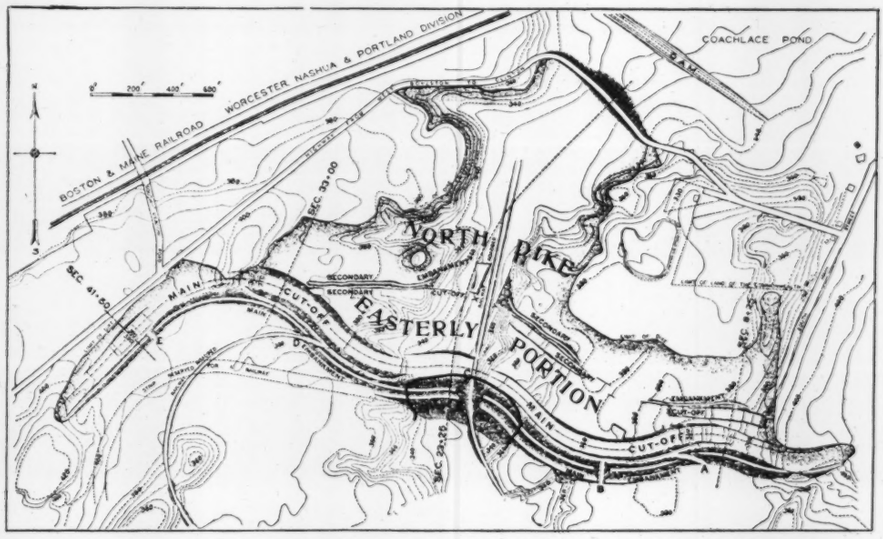


FIG. 1. PLAN OF EASTERLY PORTION OF NORTH DIKE OF WACHUSETT RESERVOIR.

The following elevations may be serviceable in understanding the conditions at the dike and the slight danger of the serious consequences set forth by some of the "yellow journals":

	Elevation.		Elevation.
Top of Wachusett Dam	415	Bottom of riprap	383
High water, Wach. Res.	395	Water level Apr. 14	371.7
Top of dike	412		
Top of riprap and gravel facing	400		
Top of cut-off wall	396		

The slip happened (general plan of dike, Fig. 1) at the point of maximum section, where the embankment is about 80 ft. high and where there is now about 42 ft. of water. (See, also, enlarged plan and sketch sections, Figs. 3 and 4, and the views, Figs. 5, 6 and 7.) The portion that slipped into the water was about 675 ft. long, with a thickness normal to the slope of about 35 ft. It is estimated that the quantity of material thus displaced was from 60,000 to 70,000 cu. yds. At the elevation of the present water level that portion of the dike remaining is about 830 ft. thick and contains the core wall intact, except for a few cubic yards from the extreme top of the inside corner. When this great mass of earth became detached and slipped into the water its momentum carried it from 150 to 250 ft. out into the reservoir. At the same time, the heavy riprap was floated out on the earth to points marked "R" (after figures indicating soundings, as shown in the enlarged plan, Fig. 3).

In spite of the cry of some of the newspapers, it appears that the safety of the dike has in no way been affected and the stability and utility of this form of construction is not at all shaken by the displacement of a few thousand cubic yards of facing. The occurrence is a misfortune, not a disaster in any sense of the word.

One lesson to be learned from this accident is that a greater slope than 2 to 1 is necessary for an embankment built of fine material, when it is to be saturated with water.

From the soundings taken since the slide happened it appears that even if it had taken place at full reservoir the natural slope which the material has taken would have met the present surface of the dike at a point on the reservoir side of the railroad embankment and at about Elev. 400, even if the core wall had also taken the same slope. Under this adverse condition, as it is almost inconceivable that the core would be

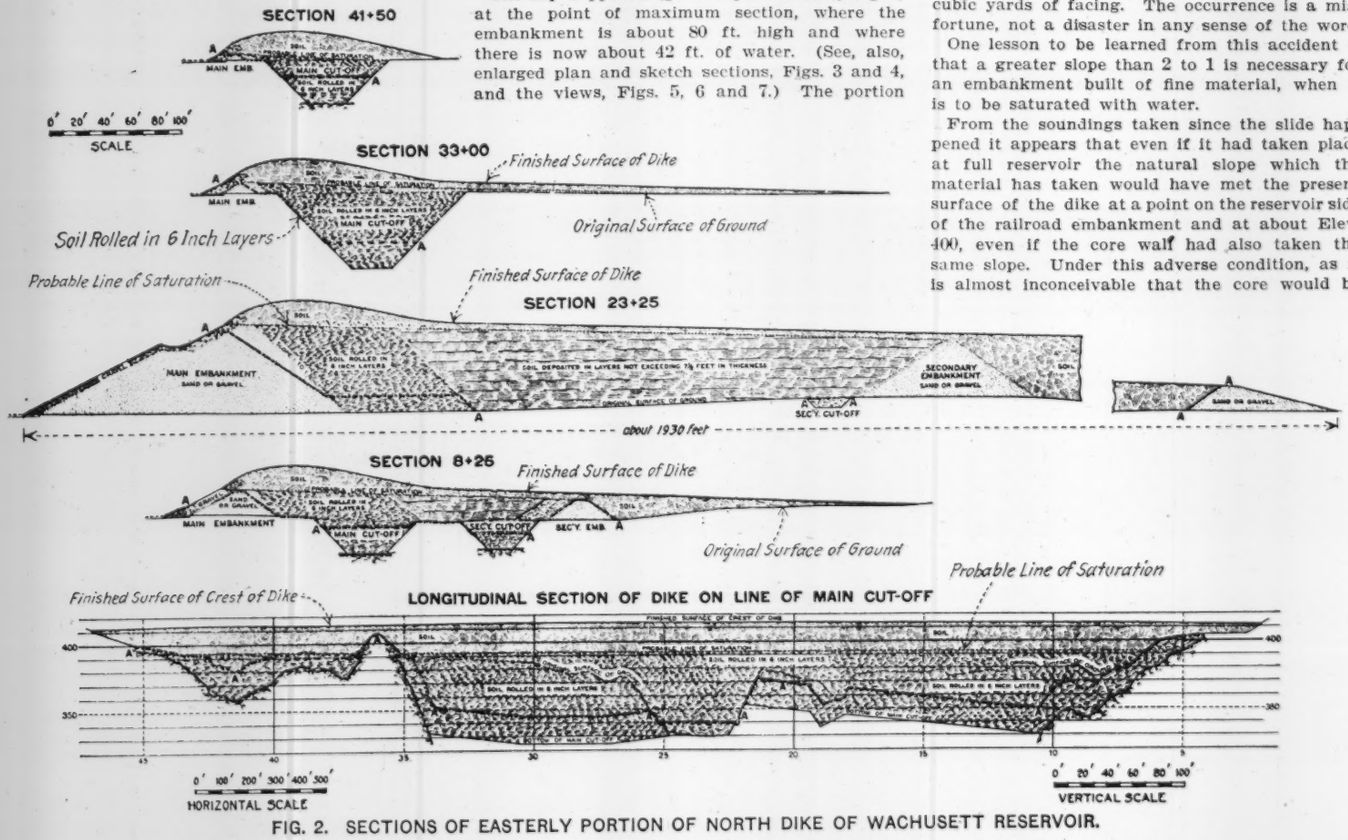


FIG. 2. SECTIONS OF EASTERLY PORTION OF NORTH DIKE OF WACHUSETT RESERVOIR.

eroded to such a flat slope, it appears that the top of the embankment would still be 5 ft. above the water surface and 60 to 65 ft. wide at this elevation.

It may be of interest to note that the Wachusett Reservoir has never been filled to the normal water level. The elevation of the water at the time of the slip (371.7) was the highest ever attained up to that time. The nearest the water had approached to that level previously was 367.75, on July 10, 1906.

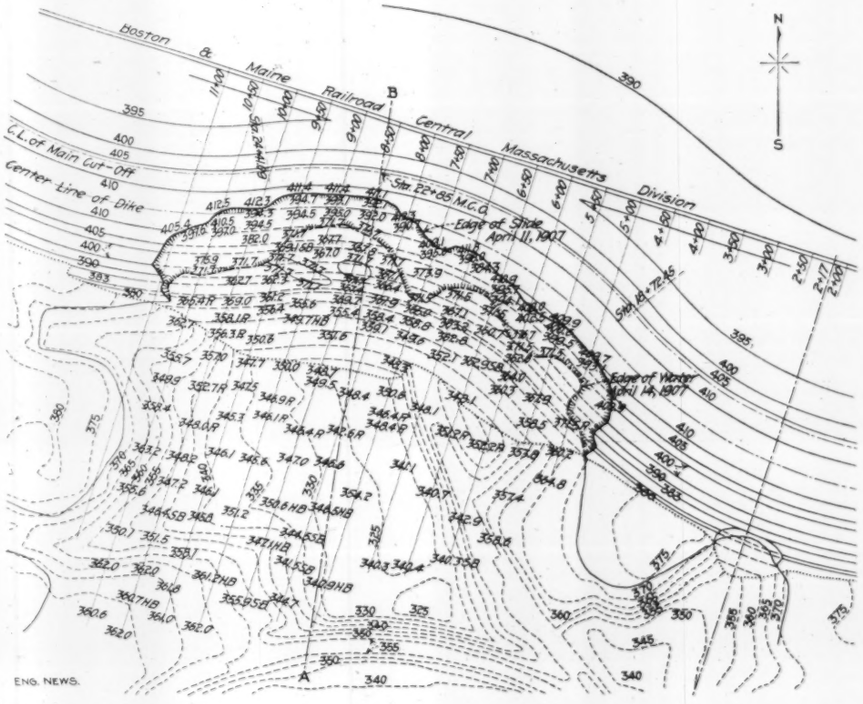


FIG. 3. PLAN SHOWING SLIP IN EASTERLY PORTION OF NORTH DIKE OF WACHUSETT RESERVOIR.

Based on original surveys of the dike, and on surveys of the slip made April 12, 13 and 14, 1907. The figures on the straight lines indicate depths of soundings along those lines on the dates named. R following the figures means that rock was struck, probably displaced riprap; H B means hard bottom; S B, soft bottom. The original contour lines are shown by full and by dotted lines, as can be readily understood.

THE VALUE OF ENGLISH TO THE TECHNICAL MAN.*

By JOHN LYLE HARRINGTON,† M. Am. Soc. C. E.

A technical man is, presumably, an educated man; and if he do not speak like one, suspicion is cast upon the entire range of his learning. When a man cannot spell correctly, or use ordinarily good grammar (and there are many university men who cannot) it is difficult to convince others that he is professionally able. The great majority of technical men occupy salaried positions in the organizations of railways, governments, constructing companies and manufacturing corporations. These positions are obtained by means of acquaintances made in a social way, by interview, by correspondence, or on account of an earned reputation. Yet I have granted interviews to many technical men who spoke like laborers, and have received hundreds of letters from them that would be a disgrace to a grammar school scholar. One who is thus ignorant of the language finds social progress substantially impossible. This may seem a trivial matter, but it is not. Matters of very large importance are often settled by favor, and favor frequently follows social position. Other things being equal, almost any one will show his friend the preference in business or professional matters. Social relations make largely for success or failure in the business or professional world. Many have received the opportunity which led to eminence through the recommendation of a casual acquaintance who was favorably impressed.

In business correspondence the value of good usage is still more manifest than in conversation. The art of letter writing, like a knowledge of grammar, is commonly considered to be within the range of everyone's learning and skill; but anyone who has had large experience in business correspondence knows that few men write good letters. Many men owe the opportunity for advancement to their ability to write a good letter.

The detrimental results of bad English in conversation or in correspondence are by no means so certain as in the more formal technical papers. In the preparation of articles for the technical press, and papers for the learned societies, there is time to study form and style and to eliminate errors due to haste; hence, when such matters are ill written, it is not unfairly argued that the writer is ignorant of the correct use of the language. The idea that a technical paper is dry at best, and that the English employed in it is of small consequence has long been proved incorrect. There is so much nowadays that is well written that no busy professional man is willing to spare the extra time and effort necessary to read and digest an ill written paper.

A merchant may advertise his wares, a manufacturer his product, but reasonable modesty and his code of ethics prevent a professional man from advertising his skill. If he does not become known by his work or his writings, he remains in comparative obscurity. His ability is clearly exposed in his writings, in which he gives to the profession his best thought; and if he cannot write easily and well he will probably not write at all, for the censorship of the learned societies is now severe and is rapidly growing more so. Every normal, healthy-minded technical man desires to leave a permanent record of the results of his best thought and work to aid his co-workers and those that come after him. An ably written description of work performed, discoveries made, or methods developed accomplishes more for the advancement of science than many well designed and well executed constructions. The latter benefit those who see them; the former may help all who can read.

Provoking and expensive errors often arise from the misunderstanding of badly expressed orders, rules and regulations. In large corporations, especially in railway, contracting and engineering companies where employees are distributed over a wide area, it is impossible for an officer to give individual instructions, or to see personally that they are carried out; hence, general instructions must be so clear that they cannot be misunderstood or evaded. It is hardly necessary to say that the consequences of a mistake in train orders, in instructions regarding breaking track for repairs or renewals, or for making temporary construction to span washouts, may result in expensive and fatal accidents. And even minor errors, oft repeated, may prove very costly.

But the preparation of reports, specifications, and contracts is the most particular and momentous task the technical man has to perform. It is not enough to be careful in a general way. Every word, every phrase, every sentence, has a direct and vital bearing on the work governed by the documents. I have known the presence in a contract of a single word of equivocal meaning to cost one of the parties many thousands of dollars, though when the contract was drawn there was no question regarding the intent of the parties to it.

Notwithstanding the vital importance of clear, concise and full expression in such documents, it is not uncommon to find specifications and contracts so bad in their construction that they fail utterly in their purpose. Let me quote in illustration from the specifications, prepared by an architectural firm of some repute, for the construction of a building which cost nearly $100,000.

"Material and Workmanship. The entire frame work, columns, beams, etc., as indicated by the framing plans, or as specified, is to be of wrought steel, of quality hereinafter designated, all materials to be provided and put in place by this contractor. All work to be done in a neat and skillful manner, and is to guarantee the construction and workmanship with a bond equal to amount of tender for a term of five years, satisfactory to the proprietor and architects, to properly carry or support the loads it is designated to carry, namely its own weight, the weight of the several floors, roof and walls resting thereon, a 10,000 gravity tank, and the pressure of any wind which may not be designated a hurricane, and future three stories. * * * The floor beams are to be calculated for a maximum load of 150 lbs. to the sq. ft. (using C type IV. of the Clinton Fire-Proof System, of Clinton, Mass.). The columns are to be calculated for a vertical load above mentioned and for horizontals and wind pressure and snow pressure, also roof. The whole to be calculated heavy enough for three additional stories on building should they be put on at any time, with connections at top columns to receive future columns. The columns on ground floor supporting front to be calculated in same proportion with all the rods necessary where shown. The whole of the columns to be one size throughout, those that carry more weight reinforced, and all columns to be kept as small as possible in proper construction. Each column to have ⅞-in. holes bored or punched every 4 ft. 6 ins. in height on each corner (for use of other trades to fasten metal lath)."

The building was constructed under these specifications, not according to them; that would be impossible. But it is hardly necessary to say that the proprietors interested were not safeguarded. The wretched paragraphs quoted are no worse than a contractor finds in specifications almost every day, for they are composed, as a large number of engineers and architects compose their specifications, by copying and combining sentences or paragraphs from various sources, instead of by writing them from fundamental knowledge of the construction desired. In such instances the client is protected infinitely more by the honesty, knowledge and skill of the contractor than by those of the architect.

Very few railway specifications for complicated structures are so well written that a contractor cannot comply

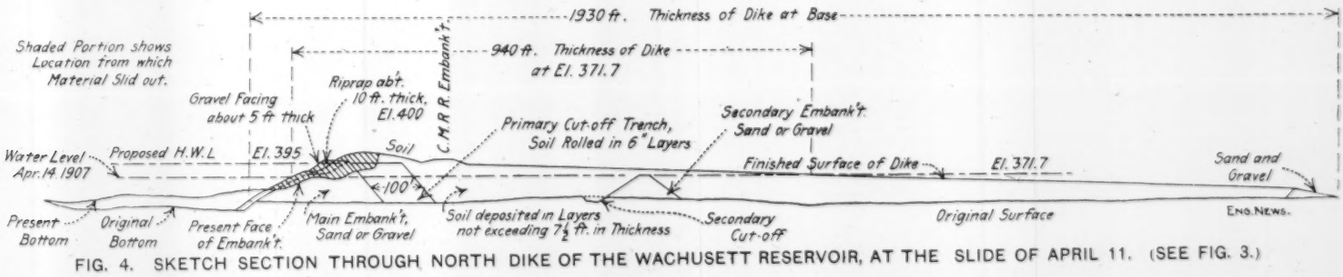

1930 ft. Thickness of Dike at Base
Shaded Portion shows Location from which Material Slid out.
940 ft. Thickness of Dike at El. 371.7
Gravel Facing about 5 ft. thick
Riprap abt. 10 ft. thick, El. 400
C.M.R.R. Embank't.
Primary Cut-off Trench, Soil Rolled in 6" Layers
Secondary Embank't. Sand or Gravel
Water Level Apr. 14 1907
Proposed H.W.L.
El. 395
Soil
Finished Surface of Dike
El. 371.7
Sand and Gravel
100'
Present Bottom
Original Bottom
Present Face of Embank't.
Main Embank't. Sand or Gravel
Soil deposited in Layers not exceeding 7½ ft. in Thickness
Secondary Cut-off
Original Surface
ENG. NEWS.

FIG. 4. SKETCH SECTION THROUGH NORTH DIKE OF THE WACHUSETT RESERVOIR, AT THE SLIDE OF APRIL 11. (SEE FIG. 3.)

†Consulting Engineer, Kansas City, Mo.
*Extracts from an address before the Technological Society of Kansas City.

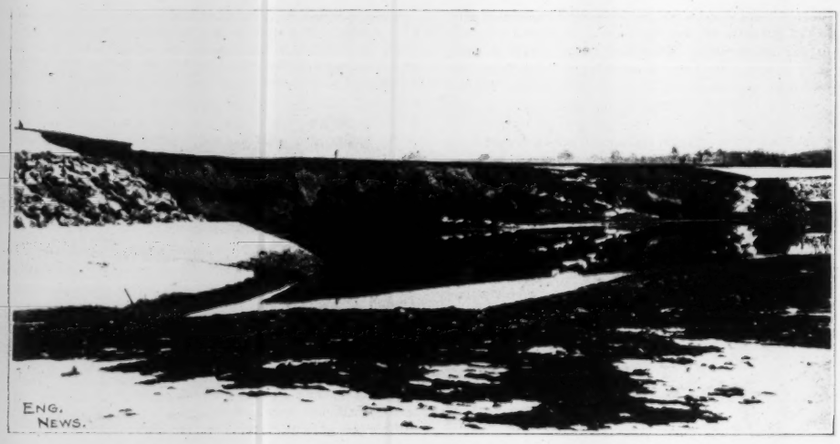


FIG. 5. VIEW OF SLIP IN NORTH DIKE OF WACHUSETT RESERVOIR.

with them to the letter, yet give the company construction far inferior to what the writer of the specifications intended, and thereby gain for himself material advantage.

The lawyers and the courts are kept busy rectifying the blunders of other professional men who do ill what they are paid to do well. I know of one contractor who has grown gray in the business of constructing buildings, who has never completed a contract without a law suit, and who has never lost a law suit. This speaks ill for the work of the architects under whom he worked, yet they are probably no worse than their fellows. If it were not good policy to be reasonably honest, many another contractor might easily approach his record.

CAPACITY FOR SERVICE AN IDEAL IN TECHNICAL EDUCATION.*

By FREDERICK REMSEN HUTTON,† M. Am. Soc. M. E.

There are two points of view possible. The one regards the educational center as a place to which the student comes to receive a discipline of mind by study and perhaps also a discipline of body by reasonable athletics. It is the purpose of this discipline to make a better man of him and to equip him mentally with a useful kit of tools in that department and give him some knowledge and skill in their use. The nature of the gymnasium apparatus used in this training process, which is the list of subjects which he shall study, is held to be of secondary consequence provided only it is perfect of its kind. That which has been proved to be perfect of its kind by the experience of the fathers and by the conditions of an aristocratic country, has a distinct presumption in its favor.

At the other extreme is the view which regards the school as a fountain or well-spring of information and of facts to be imparted by skilled and expert teachers. These are to fit the graduate to deal intelligently with the problems of actual life, since he has come to know the laws which govern practical affairs and has absorbed some of the garnered experience of the skilled professors who have worked with him. Life will furnish the discipline fast enough after graduation, but gives little opportunity to learn the laws except by hard knocks. Let us, therefore, concentrate our effort on acquiring the knowledge. This is the philosophy underlying the successful effort of the correspondence school method.

It seems to me that there need be no contradiction in these two requirements provided that each is rightly interpreted. The difficulty is to attain both ideals in a limited period. The safe middle course is so to use the study and the acquiring of physical fact and of experimental data upon matter, force and their laws, as to make such study a discipline for the mind and heart. This is the trick and the skill of the competent and successful teacher. Either extreme has its own dangers.

If the student spends his four years in study of antiquities or of abstract science unrelated to the ordinary activities of life, and has pursued literature and history as culture subjects, unrelated in their bearing to present day thought, he may become polished and outwardly cultured. But the first man who tries to lick him into usable shape in active business usually finds him less available as the result of equal labor than the office boy or the apprentice, who has begun at another round of the economic ladder.

The graduate also from this system of education has usually been favored with the modern system of practically free election of subjects of study in his college. This possibility of doing what he likes and which appeals to him, gives the young man a mistaken conception of the way things are done in the life of actual affairs; and the change from one environment to the other is so sudden and abrupt that he resents it and is unhappy or useless under it. Actual life forces him to a process, which seems to him like unlearning something which he has worked to get. Both employer and employed in their discontent form an opinion unfavorable to all sorts of higher education because the one sort under comment proved to be ill-chosen for the purpose in hand.

The great danger of the other system at the other extreme is that it should fall short of its disciplinary value because the student fails to see clearly what is his own function in the education process. It is possible that both teacher and student permit the latter to become a mere mass of absorptive tissue, taking in information and knowledge as does the dead sponge rather than by a process similar to that which is exhibited by the living tree. The lecture system of instruction by gifted experts is particularly open to this danger, since the student can be so easily lulled into a Nirvana of admiring idleness of mind, or into a state in which presence of body concurs with a practical absence of mind in the class room.

FIG. 7. VIEW OF SLIP IN NORTH DIKE OF WACHUSETT RESERVOIR.

Of what use is an extensive assortment of note books containing data, such as are gathered in our best engineers' pocketbooks, if the young man has not been trained to use his faculties or exercise his powers upon them? Worse than this, is the possibility of making wrong use of valuable data and truths because still uneducated in spite of his knowledge. No more useless product of an alleged educational process is turned loose on the industrial community than a so-called educated man, whose capacity is limited to a bookful of assorted recipes for producing certain results.

But when the thing is done right and the man is forced to think correctly, persistently, and to a definite and positive result, then the training in knowledge of physical law, in observation of phenomena, in constructive combination of apparatus for their study and in deduction from experiment, is, in my opinion, the most valuable there can be. There is no quality or attribute so valuable in any environment as that which we call initiative. This has been cleverly defined as the ability to do the right thing at the right time without being told.

The classic or purely literary training does not foster this power of initiative. On the contrary, the perfectness of the classic models and the inevitableness of the study of the past tends to discourage and dissipate this power, unless the young man finds an outlet and a discipline for it in athletics, in the management of college journalism, and the control of musical or dramatic interest.

The training in the mechanical laboratory of the technical school, on the other hand, can be directly and of purpose aimed to foster and stimulate this power. What the world calls for in its useful men is the capacity for resource to cope with conditions which have not arisen hitherto and to meet new obstacles and overcome them.

Nature rarely gives to the same man a retentive memory for things which are past, and the faculty of initiative and resource for problems of the future. The

*Extract from the Charter Day address at the Thomas S. Clarkson Memorial School of Technology, Potsdam, N. Y., March 18, 1907.

†President American Society of Mechanical Engineers, 1906-1907.

FIG. 6. VIEW OF SLIP IN NORTH DIKE OF WACHUSETT RESERVOIR.

retentive memory enables a man to show well in his college class room. He is perhaps the honor man or valedictorian under the old conditions. The other power is the one which makes him the class president, the football manager and which tells later in the world of affairs.

Hence, if my contentions are sound, and it be granted that usefulness in life is an ideal, then the education in applied science is that which can be so used as to fit a man best for a practical usefulness in an industrial community which is built upon and is dependent upon the utilization of nature's laws.

THE ENGINEERING SOCIETIES BUILDING IN NEW YORK CITY.

In our issue of Jan. 3 we gave a view of the fine new building erected for the national engineering societies through the generosity of Andrew Carnegie. The building was dedicated last week; the ceremonies extending over four successive days, the general program being as announced in our issue of April 11, p. 410. We show herewith a general view of the building, taken from the roof of a house on the opposite side of the street and also views in the main auditorium and the library. The building, however, must be seen to be appreciated, and no engineer visiting New York City should fail to pay a visit to the building and see for himself how fine a structure has been reared for the honor and advancement of the engineering profession.

The dedication exercises were remarkable throughout for their dignity and interest. The notable features of the first day's exercises were the address of Mr. Chas. F. Scott, the remarks of Mr. Carnegie and the oration by President Arthur Hadley, of Yale University. The following is an extract from Mr. Scott's remarks:

This building, simple, dignified, and appropriate to its intended uses, is to be the home of the engineering societies. These societies are the expression of engineering forces, and engineering forces are fundamental to the achievements of our age. I ask you to realize that the engineer has been foremost in bringing about our present civilization, and that to him new and larger problems are continually being presented.

The significance of this building is not in the past, nor in the present, but in the future; for the vitality which has prompted engineering development in the past is unabated now, and will continue with increasing force in the future. Witness this event, a gift of a million and a half for buildings, supplemented by a million more, the largest investment for engineering in the history of the world, and this audience of a thousand men, representative of science, engineering, education, literature, art, and government, gathered with sympathy and joy to bid Godspeed to the work we here inaugurate, and acclaim this day the beginning of a new era in engineering.

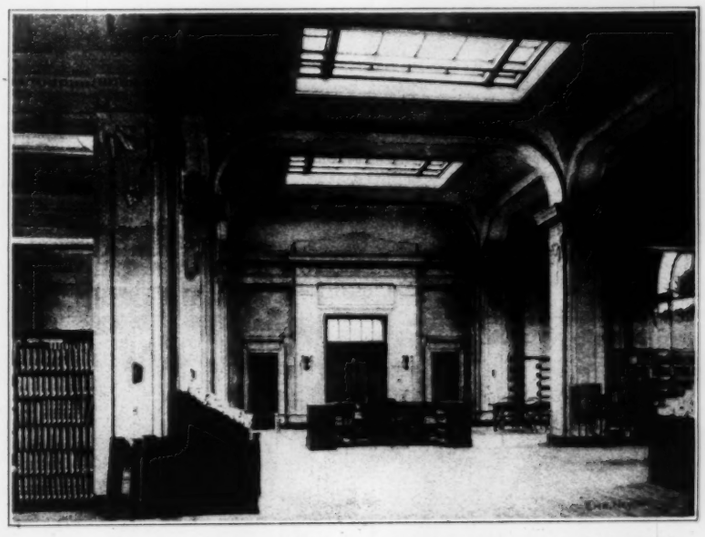
Mr. Carnegie, it has been your great privilege to make this possible. You provided money; it has been transformed into bricks and mortar. But your letter gives more than money—in it is an ideal: "a union building for you all"; that, too, has transforming power; already the "harmonizing feature" is an active force, our societies are working together, they are getting a broader view of their position, and new inspiration for the large work which lies before them.

The subject of President Hadley's oration was "The Professional Ideals of the Twentieth Century." We print the following extract:

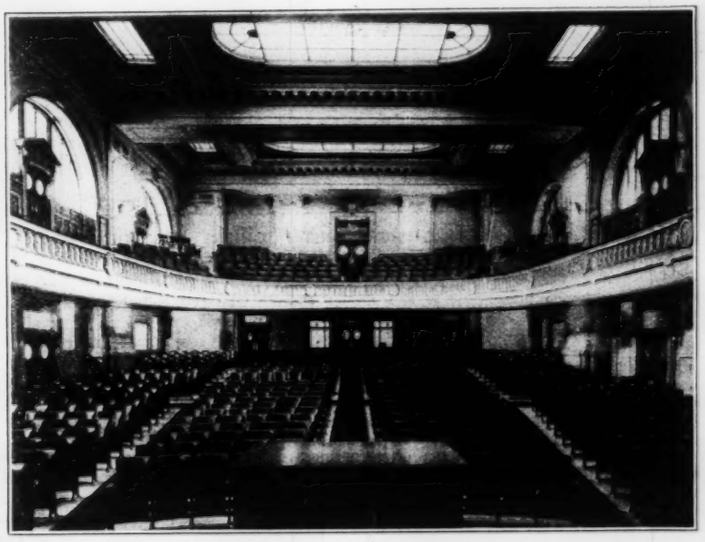
A building like this is the best monument to what the century has accomplished. The really important part of the history of a nation is the development of its ideals and standards. The specific things that it does are important not so much for their own sake, but for the sake of the evidence they give as to the trend of a nation's thought. It is not the census figures which decide whether a nation is great or small. It is the industrial methods and educational ideals which these census figures indicate. And in like manner it is not the buildings and machines and railroads and mines which constitute the important part of the history of the engineering profession. The real thing for which we care—the thing that helps us to understand the past and inspires us with hope for the future—is the story of the men who did the things—their struggles and their discoveries, their trials and their successes.

The men who did more than anything else to make the nineteenth century different from the other centuries that went before it were its engineers. Down to the close of the eighteenth century the thinking of the world was dominated by its theologians, its jurists,

THE ENGINEERING SOCIETIES BUILDING, WEST 39TH ST., NEAR 5TH AVE., NEW YORY CITY; VIEW FROM THE ROOF OF A BUILDING ACROSS THE STREET.



A VIEW IN THE LIBRARY; 14TH FLOOR OF ENGINEERING SOCIETIES BUILDING.



MAIN AUDITORIUM ON 3D FLOOR OF ENGINEERING SOCIETIES BUILDING; VIEW FROM THE STAGE.

and its physicians. These were by tradition the learned professions, the callings in which profound thought was needed, the occupations where successful men were venerated for their brains. It was reserved for the nineteenth century to recognize the dominance of abstract thought in a new field—the field of constructive effort—and to revere the trained scientific expert for what he had done in these lines. Engineering, which a hundred years ago was but a subordinate branch of the military art, has become in the years which have since elapsed a dominant factor in the intelligent practice of every art where power is to be applied with economy and intelligence.

A building like this is therefore the symbol of all that is most distinctive in the thought of the century that has gone by. A hundred years ago we might have had a building in honor of theologians, or of lawyers, or of physicians; but one that symbolized the achievements of the engineer was beyond men's dreams, because the world at large had neither felt the need of his work nor dreamed how soon it should be seeking his leadership. I have spoken of this building as a monument, but that is, after all, not the proper word.

A monument implies that a man is dead, or at any rate that he has so nearly reached the limit of his growth that he might just as well be dead. Engineering has not yet reached the limit of its growth. It has not come to the time when a complacent survey of the past will take the place of toilsome planning for the future. Not a headstone do we want; but a milestone—a point at which our measurement of what has been already done serves as an inspiration for the journey yet to be traversed.

It is not enough for a professional man to have technical training. It is not enough to know the specific sciences on which the practice of a profession is based. A man ought to have clear conceptions of the public service which his profession can render, and the public duty which its members owe. Thus, and thus only, can the engineer, the lawyer, the physician, or the member of any of the learned professions, rise to the full dignity of his calling.

There are two distinct qualities which must be combined in order to secure the best professional service; two quite distinct tests which work must meet in order to be pronounced first-class. One of these is the technical standard; the other, for want of a better word, may be called the ethical standard.

The man who wishes to build a good railroad must not only lay it out according to the rules of the surveyor's art, with the proper curves and grades and bridges which will not fall, but he must also have some intelligent regard to the needs of the population, the safety of travel, and the many other factors which determine whether a railroad shall be a work of public use or a source of industrial bickering and financial disaster.

This larger view of professional obligations is not so fully recognized as it should be. We have in the nineteenth century made so much progress in the technical training of doctors and lawyers and engineers that we sometimes forget that there is need of anything more than technical training. We have let the old idea of public leadership, which was prominent in the minds of the great professional men of past centuries, give place to another and narrower ideal which is fully satisfied when a man has made himself a technical expert.

Many a man of real eminence in his calling deliberately rejects the wider conception of the professional duty which I have here indicated. Perhaps he recognizes the claims of public service, perhaps he does not, but in any event he believes that these claims rest upon him as a man rather than as an engineer or a lawyer.

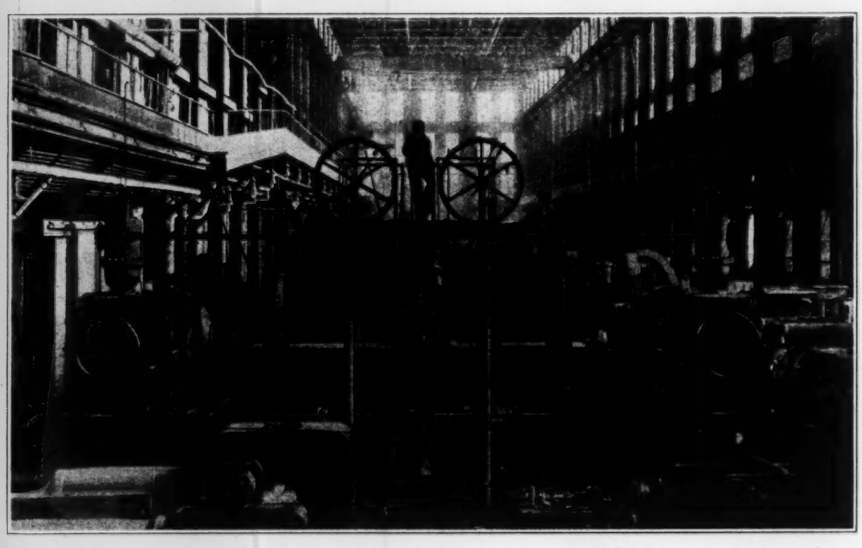
In his professional capacity he says he is hired not to tell what the law ought to be, but what it is; not to advise how a railroad can do the most public service, but how certain men with certain ideas of their own can best use the differential calculus to get those ideas carried out. This is perhaps the prevalent view of professional ethics to-day. I believe that it is a wrong view, which must menace not only the influence and standing of the professions themselves, but the general interest of the republic.

We have outgrown the day when a little common sense was sufficient for managing the affairs of the nation. They are become too complex; and this complexity gives the engineer, if he will add to his training in mathematics a training in ethics and political economy, and the fundamental principles of the law, an opportunity such as never before existed to claim and receive the position which rightfully belongs to him.

The exercises on Tuesday were chiefly notable for the remarkable array of congratulatory telegrams, letters and engrossed resolutions from engineering societies all over the world felicitating the American engineering profession on its new and splendid home. Many of these were presented or read by the official delegates in person; and those present on the stage, included among others, Sir Wm. Henry Preece, President of the Institute of Electrical Engineers of Great Britain; Mr. R. A. Hadfield, Past-President of the Iron and Steel Institute, and Dr. Henry S. Pritchett, President of Massachusetts Institute of Technology.

A LARGE MINE HOISTING ENGINE WITH CORLISS VALVE GEAR.

We show herewith a half-tone view of one of two 32 × 72-in. direct-acting Corliss hoisting engines built by the Allis-Chalmers Co. for the mines of the Boston & Montana Consolidated Copper & Silver Mining Co. at Butte, Mont.



2,500-HP. MINE HOISTING ENGINE WITH CORLISS VALVE GEAR FOR THE BOSTON & MONTANA CO.
Erected in the Milwaukee Shops of the Allis-Chalmers Co.

The two hoisting engines on this order are duplicates and weigh approximately 250 tons each. They are of the first motion type, fitted with automatic cut-off gear and governor, and also with complete steam reversing gear. Each crank shaft carries two steel hoisting drums, both provided with heavy friction clutches and powerful post brakes, all operated by individual steam cylinders and hydraulic oil-controlling cylinders so that either may be handled independently of the other or both operated in balance, as desired. The finished hoist and its duplicate will each have a lifting capacity of 34,000 lbs. from a depth of 3,500 ft. They will be operated at 140 lbs. steam pressure. This load includes the weight of the rope, which is over 6 tons. When working regularly at full capacity the engines will develop approximately 2,500-HP. These hoists will be required to make from six to seven trips per hour, night and day.

EXPLOSION OF A 5,000 KW. STEAM TURBINE.

The 38th street generating plant of the New York Edison Co., New York City, was badly damaged on the evening of Saturday, April 20, and the entire station was shut down for a time. At 9.09 p. m., while on the peak of the evening load, one of the 5,000 KW. turbine generators, while carrying its normal load, suddenly exploded and at the same instant one of the 4,000 KW. engine-driven generators burned out. The engine of still another unit was disabled also. Short-circuited switchboard connections and wires of the crippled generators caused fire which filled the large engine-room of the station with the acrid smoke of burning insulation. This interfered greatly with the work of reducing the trouble. The city fire department was called in and played water on the burning generator. This made matters worse and it was necessary to shut down the other units and attack the wreckage with axes and chemicals.

The auxiliary transmission lines of the company, connecting the main generating plants, were put into immediate use. By means of these it was attempted to distribute the load carried ordinarily by the 38th St. station on the others plants. What was not carried by these stations was handled by the storage batteries in the 23 sub-stations of the district. The load of the station in which the accident occurred is practically all of Manhattan Island from between 14th and 72d Sts. The accident caused a reduction in this area of about nine-tenths the normal electrical output. In those streets where the Edison Co. supplied current, the lights were dimmed for about half an hour.

As soon as men were able to work in the station, the wreckage was removed from the uninjured dynamos and these were put in operation again, greatly relieving the trouble. The lowest voltage in any section of the affected area was for a few moments about 80.

The unit which exploded was a 5,000 KW., 60-cycle Curtis turbine alternator, designed to be run at 514 r. p. m. It is to be presumed, from the facts made public, that the turbine ran away, due to defective action of the governing mechanism, and the tremendous centrifugal force thus developed caused the alternator to fly apart. The sheet steel casing of the turbine was torn to pieces and bits were embedded in the brick walls. A section of the unit was driven through the rear wall of the power house, making a 20 ft. hole. The dynamo room is provided with six galleries and pieces of metal were thrown to the top one. The damage is placed at $15,000. While there were about 200 men in the building, no serious injuries have been reported.

NOTES FROM ENGINEERING SCHOOLS.

UNIVERSITY OF WISCONSIN.—The seventh annual session of the Summer School of Artisans held under the direction of the College of Engineering, will open June 24 and continue for six weeks. Courses in "engines and boilers"; "applied electricity"; "mechanical drawing and machine design"; "materials of construction, fuels and lubricants"; "shop work"; and "manual training" will be offered. The summer school is run for the benefit of artisans, such as machinists, carpenters, engineers, apprentices, etc., who wish to gain a better understanding of their work, or else qualify themselves for better positions.

COMPULSORY ADOPTION OF THE METRIC SYSTEM has been defeated in Great Britain. A bill recently before Parliament proposed to compel sales and contracts to be made in the metric system after April 1, 1910. In the debate it was claimed than 80 to 90% of the machinery manufacturers of the country were opposed to the bill. In the shipping industry, measures of draft, displacement and tonnage would have to be altered throughout the world. The cotton industry, too, is

carried on the world over in English units. The motion to pass the bill to a second reading was defeated by a vote of 150 to 118.

A REAR COLLISION occurred between a freight train and a fast passenger train on the Southern Ry., at Birmingham, Ala., April 21. The accident was caused by an operator allowing the passenger train to enter a block before the freight had left it. The freight was drawing a "dead" engine at the rear, and this engine, together with the passenger engine, was wrecked, as well as the baggage and mail cars of the passenger train. The collision threw several freight cars across the eastbound track, and before warning could be given these were crashed into by a wrecking train bound for Heflin, Ala. This second collision ditched practically all of the freight cars, and wrecked the wrecking train. Two trainmen were killed and a half dozen others seriously injured.

A FIRE in the mine of Dos Estrelles Mining Co., of Elore, Mexico, killed some 14 miners April 12, according to reports from Mexico City. These reports also stated that the mine was still burning and rescue work progressing very slowly.

EARTHQUAKES IN MANY REGIONS of the world were reported during the two or three days following the destructive Mexican earthquakes of April 14 to 16. Shocks of more or less intensity were felt in Constantinople, in the town of Oskhabad (Transcaucasia), and in the cities of Murcia and Tortosa, southern Spain, on April 17. Two days later, April 19, slight tremors were felt at Charleston, S. C., and in Switzerland, and heavier shocks in the Philippine Islands and in northern Algeria. The volcano of Puyehue, in Peru, was reported in eruption; the Colima volcano, in the State of Guerrero, Mex., continued in heavy eruption. Later reports from the Mexican earthquake district confirm the impression reported in this column last week, that nearly all of the State of Guerrero was devastated, and that several hundred, possibly as many as 500 to 1,000, persons lost their lives.

A NEW TERMINAL STATION AT CHICAGO is projected, to take the place of the Polk St. station. This station is owned by the Chicago & Western Indiana Ry. and used by five other tenant lines. Additional land for the new terminal has been purchased gradually during the past few years and, according to reports, the railway company is nearly ready to undertake the work of construction.

A SALT WATER FIRE PROTECTION SYSTEM for San Francisco has been reported on by Mr. T. P. Woodward, City Engineer. A high-pressure system is proposed, consisting of three pumping plants on the water front, necessary mains, and two 5,000,000-gal. reservoirs, the latter to be located on Twin Peaks near Twentieth and Stanyan Sts. Two of the pumping plants would have ultimately a capacity of 16,000 gals. per min. each; one of these would be located near the foot of Second St. and the other near the foot of Van Ness Ave. The third station, of 8,000 gals. per min. capacity, would be located near the Union Iron Works. The pumping engines would be founded on solid rock and would be designed to work against a pressure of 300 lbs. per sq. in. In addition to the pumping stations, at least two fireboats are recommended, each with a capacity of 12,000 gals. per min. against a pressure of 150 lbs. per sq. in., or 6,000 gals. against 300 lbs. It is also proposed to repair the fire systems that were in use before the earthquake, and to build a number of new ones ranging in capacity from 25,000 to 100,000 gals. Reinforced concrete is the material proposed for these systems.

THE MISSISSIPPI RIVER BRIDGE to be built from Venice, Ill., to the north end of St. Louis, Mo., for the electric railway of the Illinois Traction System is to cost about $2,500,000. This bridge was noted in the article on new bridges at St. Louis in our issue of March 21. According to report it will have a central span of 523 ft., with two intermediate or flanking spans of 521 ft., and two shore spans of 300 ft. In addition to a double-track railway it will have two roadways and sidewalks. The railway will extend through St. Louis to a terminal station at 12th and Lucas Sts.

TWO NEW FIRE BOATS for the New York City Fire Department were launched April 16, at the ship yards of Alexander Miller & Brother, Newburg, N. Y. They were christened the "Thomas Willett" and the "James Duane." Each boat is 131 ft. long, with 27 ft. beam and a depth of 14 ft. They are to be driven by 150-HP. steam turbines and will be fitted with centrifugal pumps, having a capacity of 10,000 gals. per minute.

OFFICIAL NOTICE prohibiting the pollution of the Passaic River by sewage discharge after Dec. 12, 1912, has been served by John S. Gibson, Clerk of the Passaic Valley Sewerage Commission, Newark, N. J. The following cities and towns are affected: Newark, Orange, East Orange, Bloomfield, Glen Ridge, Montclair, Belleville, Aquackanonk Township, Garfield, Passaic, Paterson, Wallington, Nutley, Kearny, East Newark, Harrison, North Arlington, Union Township, Rutherford, East Rutherford. Under recent legislation the various communities can construct joint or separate disposal works. It is supposed that the trunk sewer scheme, with a discharged in New York Bay or Kill von Kull, will be revived, but this remains to be seen.

A TUNNEL UNDER NORTHUMBERLAND STRAIT from the mainland to Prince Edward Island is proposed in an estimate submitted to the Canadian government. The proposed tunnel will be 7½ miles long and reach a depth of 150 ft. below water level, and can be built at an estimated cost of $15,000,000. The proposed line is from Cape Tormentine in New Brunswick to Cape Traverse, Prince Edward Island, at the narrowest part of the strait.

THE TALLEST BUILDING IN THE WORLD is once more proposed, this time at Pittsburg, Pa. Plans have been submitted to the County Commissioners there for the erection of a 40-story addition to the Court House for Allegheny County, which will rise 700 ft. above ground level. The highest building so far attempted is the tower on Metropolitan Life Building in New York City, which is 658 ft. above the sidewalk. The County Commissioners of Allegheny County have not decided as yet upon the 700-ft. tower, but have the matter under consideration.

MOSQUITO EXTERMINATION WITHIN DOORS, by means of a compound of camphor and carbolic acid called "Culicide," was outlined at some length in our issue of April 12, 1906. That article was based on a report by Passed Assistant Surgeon Berry, detailing experiments made by him at Tampa Bay quarantine. In the "Public Health Reports" of the Public Health and Marine Hospital Service for March 29, 1907, 42 experiments on a total of 10,000 mosquitoes, made at Mobile, Ala., by Passed Assistant Surgeon Francis are reported. The chemical agent in this case appears to have been practically the same as the culicide used in the previous experiment, although it is here called by the more ordinary name of camphor-phenol. Surgeon Francis lays stress upon the desirability of having the protection afforded to mosquitoes in extermination tests "assimilate as nearly as possible those which the mosquito brings to his rescue in nature." He states that it is well known that mosquitoes hide among clothes in wardrobes, behind washstands, in the bunks of staterooms on ships, in dark jugs, even going down narrow necks of jugs to deposit eggs in water. Bearing these facts in mind, some of the mosquitoes in the tests reported on were "placed in a cage on the floor beneath a bed, the sides and ends of which are covered with blankets falling to the floor, except on one side, on which the blanket lacks 4 ins. of reaching the floor." Since the camphor-phenol fumes will not penetrate blankets, reliance has to be placed upon their dissemination by the diffusion of gases. The general result of the tests was considered unsatisfactory, while other tests, in which ordinary sulphur rolls were used, were much more effective. Those interested in details can doubtless secure the full report by addressing the Public Health and Marine-Hospital Service, Washington, D. C.

THE DROP MANHOLE PATENT granted to James P. Bates in 1892, and assigned to Alexander Donahey, of Kirksville, Mo., has been held to be invalid by the U. S. Court, sitting at Keokuk, Iowa. A suit to recover royalties of $10 each for every manhole on the sanitary sewerage system of Centerville, Iowa, was brought in 1906. At the hearing on April 16, 1907, the court decided that the drop manhole involved was not patentable. This decision was given after the plaintiff rested his case, but before the defense had produced its evidence as to priority of use. The plaintiff took a non-suit. Mr. M. G. Hall is City Engineer of Centerville, and to him we are indebted for the information given.

PERSONALS.

Mr. E. A. Kingsley has been elected City Engineer and Superintendent of Public Works for the city of Little Rock, Ark.

Mr. H. D. Richardson, has resigned as Assistant Superintendent of the Nipissing mines, Cobalt, Ont., and he will remove to Boise, Idaho.

Mr. T. H. Watkins, of Scranton, Pa., has been elected President of the Pittsburg, Binghamton & Eastern R. R., to succeed Mr. F. A. Sawyer, resigned.

Mr. J. G. Gwynn, and not Mr. G. W. Gwynne, as stated in our last issue, has been appointed Chief Engineer of the Denver & Rio Grande R. R.

Prof. C. R. Richards, Head of the Department of Mechanical Engineering, University of Nebraska, has been elected Dean of Engineering at that institution.

Mr. A. T. Dice has been appointed General Superintendent of The Williams Valley R. R.; Mr. W. H. Keffer, Superintendent, and Mr. William Hunter, Chief Engineer.

Mr. W. H. Maddocks has been appointed Assistant Superintendent of Machinery and Equipment for the Missouri, Kansas & Texas Ry., with headquarters at Parsons, Kan.

Mr. Alex R. Holliday, formerly Engineer Maintenance of Way for the Pennsylvania R. R., has become associated with the National Concrete Co., 805 Tractional Terminal Bldg., Indianapolis, Ind.

Mr. E. F. Carry, Second Vice-President and Chicago Manager of the American Car & Foundry Co., has been elected First Vice-President and General Manager, to succeed Mr. W. J. McBride, resigned.

Mr. F. S. Elliott, Assistant Superintendent of the Great Northern Ry. at Larimore, N. D., has been promoted to be General Superintendent at Spokane, Wash. He will be succeeded by Mr. F. D. Kelsey.

Mr. Henry W. Taylor has been appointed Assistant Engineer to take charge of the survey for an outlet sewer for the City of Rochester, N. Y. He has been acting as Assistant Engineer for some time past.

Mr. Nathan C. Grover, formerly Assistant Chief Hydrographer of the U. S. Geological Survey, has accepted the position of Assistant Hydraulic Engineer, J. G. White & Co., Inc., Engineers, Contractors, 43-49 Exchange Pl., New York City.

Mr. J. B. Diven, Master Mechanic of the Cumberland Valley R. R. at Chambersburg, Pa., has been appointed Assistant Engineer of Motive Power for the United Railroads of New Jersey. Mr. Taber Hamilton succeeds him as Master Mechanic.

Mr. Theodore Belzner, Jun. Am. Soc. C. E., has resigned as Inspector of Steel Construction for the Rapid Transit Railroad Commission of New York, to become Inspector of Steel, Blackwell's Island Bridge, Department of Bridges, New York City.

Mr. Henry C. Schmidt, Superintendent of the Minas Dolores y Anexas plant of the American Smelters' Securities Co., at Matehuala, San Luis Potosi, Mexico, has resigned to become Superintendent of Mines for the National Metallurgical Co., of that place.

Mr. R. R. Carr Harris, for the past three years in charge of a section of the Guelph & Goderich Ry. of Ontario, Canada, has been appointed Engineer in charge of construction for the Canton-Hankow Ry., China. He is a graduate of the Kingston Royal Military College.

Mr. R. B. Hayes, Superintendent of Construction, Public Buildings, for the U. S. Government, has been relieved from duty at Vincennes, Ind., and placed in charge of the Custom House at Baltimore, Md. He succeeds Mr. George O. Von Nerta, placed in charge of the Post Office at Atlanta, Ga.

Mr. Rudolph Hering, M. Am. Soc. C. E., 170 Broadway, New York, and Mr. W. G. Kirkpatrick, M. Am. Soc. C. E., City Engineer of Jackson, Miss., and a member of the firm of Kirkpatrick and Johnson, have been appointed Consulting Engineers to inspect the recently completed portions of the sewerage system of New Orleans.

Mr. R. A. Rutledge has been appointed Resident Engineer of the Southern and Galveston divisions of the Gulf, Colorado & Santa Fe Ry., to succeed Mr. M. T. Pratt, resigned. His headquarters are at Temple, Tex. Mr. C. C. Boyer has been appointed Resident Engineer of the Beaumont Division, with headquarters at Beaumont, Tex. He succeeds Mr. Rutledge.

Obituary.

Thomas B. Riter, President of the Riter-Conley Mfg. Co., of Pittsburg, Pa., died at his home in that city, April 23, of Bright's disease, aged 67 years.

Anson F. Harrold, President of the American Electrical Transformation Co., died at his home in Barrington, R. I., April 18, of tuberculosis of the throat, aged 38 years. He was a graduate of Princeton University.

J. D. Sullivan, Superintendent of the Halifax & Southwestern Ry., died at his home in Bridgewater, N. S., April 11, of pneumonia, aged 38 years. He was a native of the United States, but had resided in Canada for some time, formerly being connected with the Canadian Pacific Ry., and later with McKenzie & Mann.

Thomas Venners, formerly Superintendent of the Keystone Rolling Mill at Pittsburg, Pa., died at Brooklyn, N. Y., April 18, aged 84 years. He was born in England and there learned his trade. In 1859 he was made Superintendent of the Round Oak Iron Works, Brierly Hall, Staffordshire, England. Ten years later he came to the United States and erected a rolling mill at Portsmouth, O. Later he took charge of the steel works